· ENGINEERING NEWS-RECORD ·
OCTOBER 13, 1938

THE WEEK'S EVENTS

Money Allotted for New England Floods

Federal-state deadlock that has held up New England flood control work for two years is ended

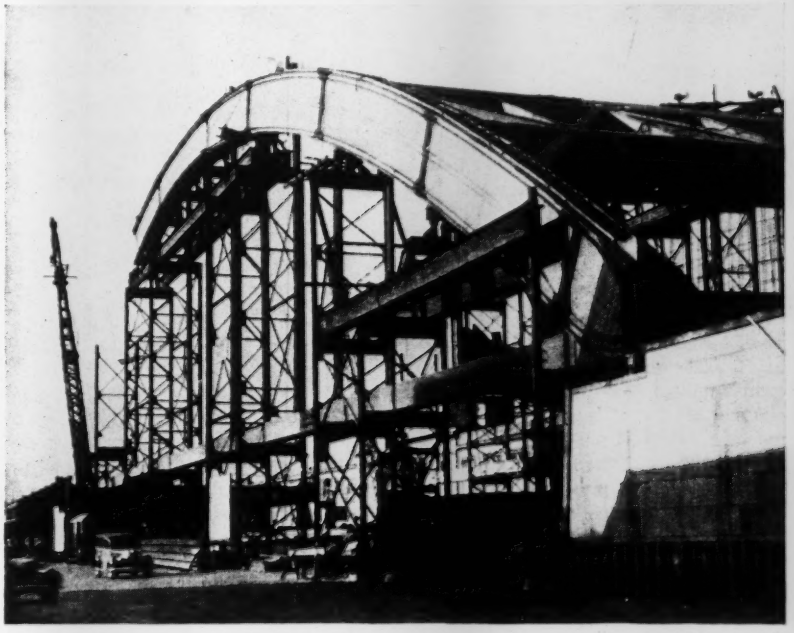
Following the hurricane and floods in New England, three federal agencies have allotted or have agreed to allot a total of $11,500,000 for construction of flood control projects in the Merrimack and Connecticut River valleys. Thus ends a two-year federal-state deadlock due to controversy over control of incidental power that has held up construction.

The Secretary of War has officially alloted $4,750,000 from regular appropriations to start work on the projects. PWA has agreed to allot $3,000,000 for the same purpose and WPA will provide approximately $2,500,000, although part of this is dependent upon further appropriations by Congress. Reservoirs projected are at Knightville, Mass., Surry Mountain, N. H., Union Village, Vt., Birch Hill, Mass., River Hill, N. H., and Franklin Falls, N. H. Local protection projects are at Hartford and East Hartford, Conn., Springfield, West Springfield, Chicopee, Northampton and Holyoke, Mass.

Reservoirs first

So far as reservoir construction is concerned, there will be no delay in starting operations. Steps have already been taken to start the acquisition by purchase or condemnation by the federal government of land needed at dam sites, and four additional engineer officers have been ordered to New England to supplement the regular personnel in that area. Bids will be asked on four of the six dams soon. Birch Hill and River Hill will be delayed pending the completion of plans. Because the local works were authorized after the regular annual appropriation was passed, some time will have to elapse until they are put into execution.

Under the terms of the 1938 flood control act, cooperation by the states is not necessary. Since none of the six dams will include power development or power storage, it is hoped by government officials that the states will not oppose the immediate start of construction.



ENR Staff Photo

BRIDGE WITHOUT A RIVER

CLOSURE OPERATIONS are scheduled this week on one of the most unusual bridges in the world—a 360-ft. span, two-hinged tied arch spanning Canal St. on the southward extension of New York City's West Side Express Highway. No such major structure, it is believed, has ever before been built to span dry land.

Choice of such a design in an elevated highway, which elsewhere in its 5-mile length is of deck girder type, was dictated by the desire for a column-free undercrossing for Canal St. Design of a column-supported structure was complicated by the presence of such important under-street structures as a sewage screening plant and the Holland Tunnel.

The net area of each of the arch ribs is 450 sq.in. of the tension tie, 288 sq.in. Two three-lane divided roadways, each 34 ft. wide, are carried. Designed by the Manhattan department of borough works, Walter D. Binger, commissioner, it is being erected by the Harris Structural Steel Co.

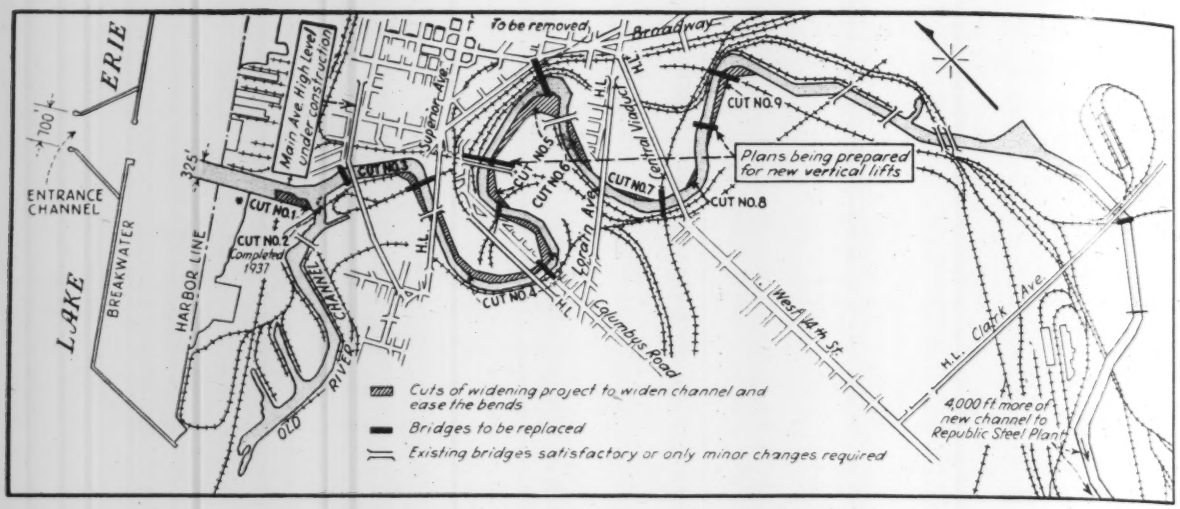
• • •

Naugatuck River Project Construction Begins

Following an emergency flood relief allotment of $9,500 by WPA, construction began Oct. 10 on dike work along the Naugatuck River at Naugatuck, Conn. Work consists of raising the existing dike 3 ft. and the installation of a 15-ft.-wide supporting embankment.

Buildings Condemned Following Tornadoes

Sixty-seven buildings damaged in the series of tornadoes (*ENR*, Oct. 6, 1938, p.417) which struck Charleston Sept. 29 have been condemned by a special board composed of the city engineer, the city building inspector, the chief of the fire department and the chief of the police department, and have been ordered partially or wholly demolished. The buildings range from one-story frame dwellings to four-story brick warehouses.



CLEVELAND GETS TO ITS CROOKED RIVER JOB

CLEVELAND, as noted three weeks ago, has received a PWA grant of $2,440,012 to add to $3,000,000 of its own funds for improving the navigation channel of the Cuyahoga River. Aptly named Cuyahoga, or "crooked," by the Indians, this stream, bisecting the city, has long presented a problem to the boats carrying iron ore, coal, grain and miscellaneous freight for the central industrial district through which it winds.

Plans for improving the Cuyahoga River have been discussed for a quarter century or more. Up to 1929, cutoffs were generally considered, but expensive rearrangement of railroad and industrial facilities was a deterrent. Finally, the study and report made by General Charles Keller in 1929, a plan which Mayor Burton has described as one for "streamlining the river," introduced the idea of merely cutting back the points and easing the principal bends. Together with the rebuilding of old, narrow bridges, the total estimated cost of the improvement is set at $14,000,000. The present project represents a substantial start on this program. What it includes is shown on the accompanying map.

In addition to the widening of the bends and the construction of over 10,000 ft. of bulkhead, the project, about to begin, will include three new vertical lift highway bridges. One, adjacent to the Big Four R.R. Bridge, will replace the present Lower W. 3rd. St. swing bridge on "Collision Bend"; Wilbur J. Watson has been retained to design this structure. A second new bridge, being designed by Wendell P. Brown, will replace the Upper W. 3rd St. swing bridge located upstream from the Central Viaduct. The third new bridge, for Columbus Road, will not reach the design stage until next year. Clear openings provided by bridges will be 200 ft. wide and 97.3 ft. high. Foundation contracts for two of the bridges will be ready for bids in November, it is expected.

The new channel, 200 ft. wide minimum and 250 ft. at docks, will be 25 ft. deep, as compared with the present 21 ft. The sizes of the cuts shown on the map vary from 50 ft. to 400 ft. wide and in length up to 5,300 ft. Work on bulkheading contract of about $100,000 will begin soon.

George B. Sowers is chairman of the Cleveland port and harbor commission and consulting engineer in charge of improving the Cuyahoga River.

Bankrupt Railways Share Grade Separation Cost

A PWA project for railway grade separation in the lakeshore Chicago suburb of Winnetka has been made possible through an arrangement by which two bankrupt railways were permitted by the courts to share in the cost. PWA has approved a grant to Winnetka of $1,553,000 and a loan of $898,000.

The Chicago & Northwestern Ry. and the adjoining Chicago North Shore & Milwaukee, although both are in receivership, have agreed to relocate their tracks close to the property line separating their rights of way, thus reducing actual grade separation cost to a minimum.

Winnetka is sponsor for the entire project, of which the estimated cost is $3,450,000. The village will pay its 55 per cent share by a special assessment. The railroads have agreed to accept an assessment of $898,000, which will be enough to cover the federal loan. The village will meet the rest of the cost by issuing bonds.

The railroads were permitted by the court to participate in the cost of the project after it was pointed out that the carrying charge and amortization on their share will be less than their present annual cost of $50,000 for operation of gates at nine crossings plus the $20,000 which is their average annual expenditure for accidents.

The financing method was worked out by the Chicago Regional Planning Association and a special committee of the Winnetka village board. The village employed Carl DeLeuw & Company as consultants to bring up to date the plan for the whole north shore district which was made in the period 1929-1932 by Walter A. Shaw.

PWA Grant Approval For Maine-N. H. Bridge

President Roosevelt has approved a PWA grant of $1,309,090 to aid in financing a highway-railroad bridge between Portsmouth, N. H., and Kittery, Me. The estimated cost of the bridge is $2,909,090. The Reconstruction Finance Corporation is handling the loan portion of the project.

Plans for the project provide for the construction of a steel bridge, including approaches across the Piscataqua River. The bridge will include a vertical lift, and is part of a project which will be about 5¼ mi. long, to be made up as follows: 2½ mi. of 4-lane road and 1 mi. of two-lane road in New Hampshire; about ¼ mi. of bridge structure; 1½ mi. of 3-lane highway in Maine, connecting U. S. Route No. 1.

Mayor La Guardia Opens A.P.W.A. Meet

Five public works men are made honorary members at New York meeting

Public works engineering is a special branch of the profession and men should be encouraged to take a life work interest in it, declared Mayor F. H. LaGuardia in an address opening the 44th annual convention of the American Public Works Association in New York on Oct. 3. To aid in the promotion of the career service concept, he suggested a national system of exchange of public works engineers between municipalities. This would provide opportunity for training experts and at the same time cities would share the advantages of employing men of varied experience.

Recognition of long and outstanding service in public works was given by the association to five men who received veteran's awards consisting of a medal and certificate. Those honored were: J. Franklin Perrine, engineer of sewers, Borough of Queens, New York; I. Charles Palmer, division of sewers, Pittsburgh; Edward F. Clark, city manager and director of public works, Kalamazoo, Mich.; George F. Koehler and Amos G. Engle, Bureau of Engineering, Philadelphia. Only public works officials who have served in one city for more than 25 years are eligible for this award.

WPA forever?

Perry A. Fellows, assistant chief engineer, Works Progress Administration, Washington, told the delegates that public works construction has now entered upon a new era in which the needs of the worker must be considered. "I think that this new era is a permanent one," said Mr. Fellows, "and regardless of what particular method we may henceforth use for the care of the unemployed and the construction of public works, these two important features of our civilization will continue to have an intimate relationship. We shall never again be able to forget the worker's needs under any program involving public works construction."

Questioning the wisdom of the present formula for allocating federal funds for public works, Walter Millard, field secretary of the National Municipal League, said that cities which had exceeded their debt limitations were unable to take full advantage of this financial aid. Philadelphia was cited as being in this status, and because the city could borrow no money it was ineligible for federal grants.

ENR Staff Photo

GUY BROWN, A.P.W.A. PRES.

Officers elected for the coming year are: Guy Brown, sewer engineer, St. Louis, Mo., president; John S. Flockhart, principal assistant engineer, Newark, N. J., and Roy L. Phillips, city engineer, Meadville, Pa., vice-presidents; and Frederick T. Paul, city engineer, Minneapolis, treasurer.

Other matters receiving attention at the three-day technical session dealt with the design and operation of public works facilities, a complete report of which will be published in next week's issue.

• • •

Further Approval Granted For New York "L" Removal

New York's Transit Commission approved the city's application to remove the 6th Ave. elevated railroad line in a finding made Oct. 3. This removes the last formal obstacle in the way of removal, the board of estimate already having approved demolition. Court action may delay removal of the structure for some time, however.

The 6th Ave. elevated's services will be duplicated when the city-owned 6th Ave. subway is put into service late in 1940. Vigorous opposition to plans for immediate removal of the elevated contends that this should not be done before the new subway is ready.

• • •

Connecticut Road Men Receive Pay Increases

Connecticut State Highway Department has announced pay increases to 195 engineering employees of the department, amounting to $55,899. The average increase per employee amounts to $300 a year. The pay rise went into effect October 1.

Sewage Works Men Meet at Hartford

Sewage treatment and stream and harbor pollution subjects discussed at three-day convention

Sewage treatment and stream and harbor pollution were subjects of discussion at the three-day joint session of the New England Sewage Works Association and the New York State Sewage Works Association held at Hartford Oct. 6–8. A large number of sanitary engineers, municipal officials, chemists and sewage plant superintendents from seven states attended.

Speakers at the meeting included A. F. Dappert, sanitary engineer of the New York State department of health, Warren J. Scott of the Connecticut department of health, C. T. Butterfield of the United States Health Service, F. W. Gilcreas of the New York State department of health, M. M. Cohn, editor of *Municipal Sanitation*. Subjects discussed were as follows: qualifications of the sewage plant operator; treatment of polluting substances in sewage; dewatering processes; public relations and public service.

Mechanical developments in the sewage handling and disposal field were shown in an exhibit by manufacturers. Leroy W. VanKleek was chairman of the committee on local arrangements.

• • •

Blue Water Bridge Opens

The Blue Water Bridge (*ENR*, Aug. 25, 1938, p. 234) was formally opened Oct. 8 when Premier M. F. Hepburn of Ontario and Governor Frank Murphy of Michigan formally cut the tape to permit traffic to flow across this latest international bridge.

• • •

13th Rockefeller Building Construction Begins

Excavation for the thirteenth unit in Rockefeller Center, New York City, a new type of commercial building combining garage facilities and office space, began Oct. 6. Three floor levels below the ground surface and three above in the 15-story building will be used for parking about 800 automobiles. As it is the first large combination office building and commercial parking garage, a special permit had to be obtained from the city before plans could be officially announced.

The general contract has been awarded to Hegeman-Harris, Inc. Lockwood Greene Engineers, Inc. will design the steel and Clyde R. Place will supervise the mechanical engineering.

Contra Costa Canal Bids Received

Keen competition on canal section job leaves outcome of award in doubt

Ten bids were received Sept. 30 for the construction of an additional eight miles of the Contra Costa Canal, important link in the central valley project of California.

On the basis of figures submitted Haas, Doughty & Jones and Marshall & Stacy, San Francisco, was low bidder on schedule 1 at $149,404 for construction of 2½ mi of canal, the 9,000-ft. Los Medanos wasteway and other appurtenant structures, including two reinforced concrete siphons and two highway bridges. Heafey-Moore Co. and Frederickson & Watson Construction Co., Oakland, submitted the low bids on schedule 2 at $161,399 for construction of 5½ mi. of canal and structures including two siphons and four highway bridges.

Haas, Doughty & Jones and Marshall & Stacy were low for the combined schedules at $315,526, and were followed by Heafey-Moore Company and Frederickson & Watson at $318,254. Both of these bidders stipulated they would accept only the combined schedules. Competition was keen and Walker R. Young, supervising engineer, said the result cannot be determined until analysis of all bids is completed.

This section of the Contra Costa Canal will extend past Antioch and Pittsburg. The Los Medanos wasteway will be an emergency spillway channel leading from the canal to the San Joaquin River. Construction is proceeding on the eight-mile section of canal between Oakley and Antioch, and all work is completed on the initial four-mile section from Rock Slough to Oakley.

• • •

Taxpayers Seek to Enjoin Covington Housing Project

Injunction proceedings seeking to halt Covington's proposed $2,500,000 federal housing projects were filed Oct. 4 in Kenton County circuit court by two residents, Jeptha and Pearl Douthitt. The petition asked that city officials be enjoined from entering into a contract with the Covington Housing Commission granting the two projects a 60-year tax exemption. The plaintiffs contend that such plans would cost Covington taxpayers thousands of dollars to enable the city to furnish the projects with fire, police and health protection, school and educational services, water distribution, disposal of garbage and other services.

Rejected Sewer System Placed in Operation

Harrison, Ark.'s PWA sewer system, which the city refused to accept because of alleged irregularities in construction, has been placed in operation, according to J. C. Penix, receiver. All of the business district and some residential sections have been tied into the new line, and service will be added to other sections as soon as repairs can be made.

Inspectors for the receiver, who is working under orders of the federal court, have found irregularities in construction which are said to substantiate the city's contention in refusing to accept the project as completed. Several blocks of homes cannot be served because the lines to them are said to have been laid too close to the surface.

CONTRACTS AND CAPITAL

ENGINEERING construction awards for the short week due to the Columbus Day holiday total $49,086,000, a 44 per cent gain over the corresponding week in 1937. This is the thirteenth consecutive week in which 1938 awards have exceeded their 1937 values.

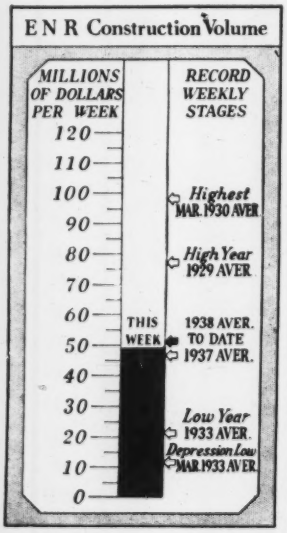
The current week's volume brings the 1938 total to $2,121,300,000, a 7.7 per cent increase over the $1,968,997,000 total for the 41-week period last year.

Public construction is 104 per cent higher than the week a year ago, but private awards are 16 per cent lower.

In the classified construction groups, waterworks, sewerage, commercial building and large-scale housing, public buildings, earthwork and drainage, and unclassified construction show increases over their totals for the corresponding 1937 week. Gains over last week are in waterworks and industrial buildings.

New capital for construction purposes for the week, $54,011,000, is 225 per cent higher than a year ago. This week's new financing is made up of $30,730,000 in PWA allotments for non-federal projects, $9,737,000 in RFC loans to municipalities, $9,073,000 in state and municipal bonds, $2,442,000 in REA loans, $2,004,000 in corporate security issues, and $25,000 in PWA allotments for federal projects.

New construction capital for 41 weeks of 1938 totals $3,217,577,000, a gain of 57 per cent over the $2,049,876,000 for the corresponding period last year.



• • •

CONTRACTS

(Thousands of dollars)

	Week Ending Oct. 14 1937	Oct. 6 1938	Oct. 13 1938
Federal	$1,983	$11,197	$9,159
State & Municipal	15,077	41,503	25,582
Total public	$17,060	$52,700	$34,741
Total private	17,099	15,254	14,345
TOTALS	$34,159	$67,954	$49,086
Cumulative 1938 .... (41 weeks)			$2,121,300
1937 .... (41 weeks)			$1,968,997

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	1937 41 Wk.	Cumulative 1938 41 Wk.
NON-FEDERAL	$1,303,653	$2,080,848
Corporate securities	478,547	334,081
State & Mun. bonds	417,041	468,938
PWA loans, grants	178,126	712,394
RFC loans	29,939	107,128
U.S.H.A. loans	.....	202,807
R.E.A. loans	.....	54,000
Federal Aid-highways	200,000	201,500
FEDERAL	746,223	1,136,729
TOTAL CAPITAL	$2,049,876	$3,217,577

FHA MORTGAGES

	1937 40 Wk.	Cumulative 1938 40 Wk.
Mortg. selected for appraisal	$483,934	$771,541

ENR INDEX NUMBERS

Index Base		1913	1926
Construction Cost	Oct.	234.30	112.63
Building Cost	Oct.	195.48	105.67
Volume	Sept.	213	93

Richard Khuen, Jr. Dies in Pittsburgh

Prof. E. W. Rettger, Cornell mechanics professor, dead in Ithaca at age of 67

Richard Khuen, Jr., for 17 years before 1931 general manager of erection for the American Bridge Co., died Sept. 24 in Pittsburgh at the age of 73.

Born in Saginaw, Mich., Khuen graduated from the University of Michigan in 1889 and was first associated in engineering work with George S. Morison. From there he went to the Erie Railroad. Subsequently he held positions with the Erie Railroad, the Philadelphia Elevated Railroad Co., and the A. & P. Roberts Co. When the Roberts Co. was merged into the American Bridge Co. in 1900, he was on the designing staff of the late C. C. Schneider, vice-president in charge of engineering. In February 1901, he was transferred to Pittsburgh as division engineer, which position he retained until May 18, 1914, when he was appointed general manager of erection. On April 1, 1931, he was appointed chief engineer.

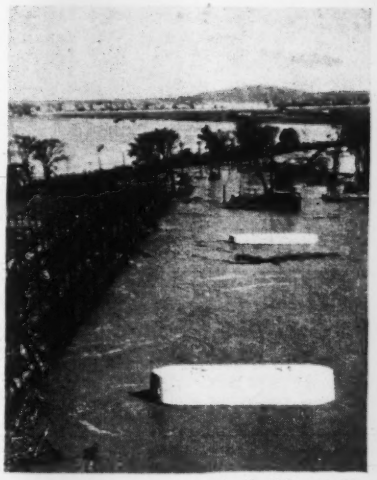
E. W. RETTGER, professor of mechanics at Cornell since 1922 and a faculty member since 1907, died Oct. 9 at the age of 67. Following his graduation from the University of Indiana in 1892, he received his Ph.D. degree at Clark University and taught mathematics at Indiana, Stanford, Princeton and Warrenburg State Normal School. He became an instructor in civil engineering at Cornell in 1907.

CHARLES H. HARRINGTON, subway construction engineer, died Oct. 8 in New York City. For the last 20 years he was associated with Patrick McGovern in building subways and water tunnels in Boston, New York and Philadelphia. He served overseas as a lieutenant with the 301st Engineers.

J. D. HOFFMAN, 70, an engineering educator at Purdue University for almost 50 years, died recently in West Lafayette, Ind.

JOHN F. SHEBLESSY, designer of a number of large Cincinnati school and church buildings, died there Oct. 4 at the age of 65.

ROBERT J. BRODIE, member of the first engineering graduating class of McGill University, died Oct. 3 in Smith's Falls, Ont., at the age of 87. Brodie was one of the engineers of construction on the Canadian Pacific and in later years city engineer of Smith's Falls.



A. T. Halteman Photo

TIME OUT FOR A FLOOD

BETHLEHEM Steel erection crews on the Calvin Coolidge Memorial Bridge across the Connecticut River at Northampton, Mass., lost a day or two but nothing more in the recent floods. Water to the floor of the old bridge did not reach the tops of the new piers. The new bridge will be a deck truss of continuous type. Two spans are erected.

FRANK L. HECKMAN, 72, former engineer with Chicago Elevated Lines and on the first railroad in the Black Hills, died in Omaha Oct. 4.

JOHN E. GIBSON, secretary of the McCabe Construction Co., Cincinnati, died there Sept. 30 at the age of 66.

CHARLES B. HEFFRON, vice-president of the Pioneer Engineering Co., Philadelphia, died there recently. He was 40.

LAWRENCE C. KELLER, an employee of the Erie County, N. Y., highway department, was killed when the crane he was operating came in contact with a high tension wire.

VIRGIL P. KNOTT, chief of the architectural and engineering section of the Resettlement Administration, Little Rock, Ark., died in Rochester, Minn., Oct. 1.

PRESTON LOCKE, 50-year-old Pasadena consulting engineer, was killed Oct. 6 at Vancouver, B. C., while on a vacation yachting trip.

HENRY WARDLAW MCALL, civil engineer on the staff of the City of Toronto, died there Oct. 1.

EDWARD W. SCHROEDER, Cincinnati contractor for 50 years, died there Sept. 29 at the age of 74.

WASHINGTON HIGHLIGHTS

Special reports by Paul Wooton

EXPLORATORY drilling has begun to determine the most desirable lock site at the Panama canal. This is the initial step of a study which will be pursued for four years to develop the best and most economical means of increasing the capacity of the canal.

It is estimated that the present capacity of the canal will be sufficient to meet the needs of traffic until 1950. Under present plans construction of new locks will be spread over ten years.

THE Reconstruction Finance Corporation on September 24 authorized a loan of $2,100,000 to the city of Greenville, Miss., for the construction of a bridge to carry the Birmingham-Dallas highway across the Mississippi River. The balance of the $4,125,000 cost is to be furnished by a PWA grant. Tolls will be charged to amortize the loan.

ON ITS first decision day of the fall term the U. S. Supreme Court on October 10 refused to consider an appeal by the West Tennessee Power & Light Company for a review of a Circuit Court decision dismissing an attempt to enjoin the city of Jackson, Tenn., from issuing bonds to construct a distribution system for TVA power. The company contended that such construction and operation would be a direct violation of the terms of its franchise.

AMONG non-federal projects recently approved by PWA are a Mississippi state highway program of $6,667,000, the public market in Kansas City to cost $3,800,000, and $2,241,000 for a bridge in Seattle.

• • •

I.C.C. Will Hear Petition For Removal of Railway

Authority to apply to the Interstate Commerce Commission for abandonment of a two-mile stretch of the Missouri Pacific Railroad's Creve Coeur branch from Webster Groves to Creve Coeur Lake in St. Louis County, Mo., has been granted to Guy A. Thompson, trustee for the railroad.

The Creve Coeur branch was completed in 1881, and from then until 1900 carried vacationists to Creve Coeur Lake resorts. Freight revenue on the route during that period was derived from transportation of natural ice from the lake to St. Louis.

Experts on Earth Dams Study Fort Peck Slide

A board of experts on earth dam design and soil mechanics, called to Fort Peck, Mont., by the Chief of Engineers, U. S. Army, has completed its examination of the slide in the face of the dam (*ENR*, Sept. 29, p. 385) and has disbanded to reconvene upon the completion of borings to determine what took place under the slide.

The board consists of Joel D. Justin, Glennon Gilboy, Arthur Casagrande, Irving H. Crosby, Thaddeus Merriman, W. J. Mead, Wm. H. McAlpine, Wm. Gerig (latter two from office of Chief of Engineers). Louis C. Hill was invited but was ill and unable to participate.

Major General Julian L. Schley, Chief of Engineers, Brig. Gen. Max C. Tyler, Assistant Chief of Engineers, and Col. C. L. Sturdevant, division engineer, met with the board at the dam.

• • •

Southampton, L. I., Opposes Fire Island Parkway

The Village of Southampton, L. I., is opposing the Fire Island improvement plan proposed by Robert Moses, president of the Long Island State Park Commission (on advertising page 28, this issue). The principal objection to the plan is that its cost would place "too great burden on the taxpayers of Suffolk County." It is further pointed out that the use of "snow fences" made of branches of trees blown down in the hurricane has already built up the dunes as much as 4 ft.

The Suffolk County board of supervisors has appointed W. Earle Andrews, former park commission engineer, and former general manager of the New York World's Fair, to conduct a $15,000 survey of the beach by Nov. 14, when all plans will be studied.

• • •

State of Pennsylvania Loses Old Canal

The old Lehigh Valley canal connecting Easton and Bristol, Pa., was taken away from the State and given to its original owners, the Lehigh Toll & Navigation Co., by a State Supreme Court decision Oct. 3.

Contending that the act of 1858 which enabled the Lehigh company to build the canal required its permanent maintenance as a public waterway, the state department of forests and waters had attempted to gain possession of the canal which was at one time used principally for transportation of coal from the anthracite region. The court, in leaving the canal in the possession of its original owners, held that the act of 1858 was merely "a condition of conveyance."

In recent years the Lehigh company has been selling water for industrial purposes from the canal's upper reaches.

• • •

Training Courses Offered Arkansas Road Men

Over 150 employees of the Arkansas state highway department have begun training classes in seven courses of study offered by their organization.

Courses are offered in highway law, practical mathematics, statistical methods, care and operation of mechanical equipment, cost accounting, business English, and public speaking.

• • •

RFC Agrees on Terms Of South Penn Road Loan

Chairman Jesse Jones of the Reconstruction Finance Corp. has announced agreement with the Pennsylvania Turnpike Commission on details of a loan to finance the Harrisburg-Pittsburgh toll highway on the old South Penn Railway right-of-way.

RFC will purchase $35,000,000 of 3¾ per cent Pennsylvania state revenue bonds to be amortized in 30 years. PWA has already agreed to make a grant of $26,100,000.

• • •

Contractor Sues Danbury For Paving Pay

Claiming that $16,713 is still due for the asphalt paving in 1936 of Main St., Danbury, Conn., Leverty & Hurley, Bridgeport, Conn., contracting firm, has brought suit against Danbury for $20,000 damages.

Work on the contract began Aug. 17, 1936 and ended Oct. 23 of the same year. The city paid $5,000 for work on Jan. 16, 1937 and a balance of $16,713 has remained since. In refusing to pay this bill the defendant claims only $5,000 was appropriated toward the work, and if there was an agreement to pay the full cost it was not official and therefore the city is not liable.

• • •

Link to Treasure Isle Opened at San Francisco

The Treasure Island-Bay Bridge highway (described elsewhere in this issue) was opened to the public Oct. 1. The regular 50-cent toll entitles the motorist to make a round trip to the island from either end of the bridge, or to cross the bridge, making a stop-off at Treasure Island.

Many Changes Made Among Army Engineers

Col. C. S. Ridley, Governor of the Canal Zone, and Col. E. L. Daley, division engineer, North Atlantic Division, both were promoted to the rank of brigadier general on Oct. 1. General Daley leaves the Engineer Corps and goes to Boston to command the Coast Artillery District.

Col. F. B. Wilby, division engineer at New Orleans, will go to New York about Nov. 1 to succeed General Daley; Lt. Col. R. G. Powell, Cincinnati, goes to New Orleans as division engineer; Lt. Col. E. H. Marks, Buffalo, succeeds Col. Powell. Other transfers include Major P. G. Burton from New York to Buffalo, Major L. H. Dillon from Portland, Ore., to New York, and Capt. D. Gullatt from Fort Belvoir, Va., to Springfield, Mass.

Col. Earl I. Brown, division engineer at Richmond, Va., retired on Oct. 13.

• • •

U. S. Chamber of Commerce Calls Building Conference

A conference looking to the stimulation of all kinds of private construction will be held in Washington Oct. 20-21 by the United States Chamber of Commerce.

The purposes of the conference, as outlined by the program committee of the chamber are: to emphasize the importance of private construction and its recovery if industry is to prosper on a permanent basis; to bring attention to promotional plans which responsible groups in the industry are carrying on to stimulate such work; to discuss obstacles to be overcome to release the normal volume of private work; to emphasize again the essentially local character of construction and the need for coordination of local efforts to stimulate private construction.

• • •

Coulee Dam Contractors Must Pay Gas Tax

Coulee dam contractors must pay the state gas tax on big trucks they contend do not travel on state highways, Superior Judge John M. Wilson has ruled at Olympia, Wash. The Mason-Walsh-Atkinson-Kier Co., contractor for the low dam, has brought suit against License Director Harry C. Huse to collect $68,915 in rebates for taxes paid. Judge Wilson held the trucks used public roads and the gas they used was therefore subject to the five-cent tax. The contractors held the roads they used, in the vicinity of Coulee dam, were under federal jurisdiction.

COMMENT AND DISCUSSION

Readers' opinions on matters that concern the engineer

Bridge Expansion Bearings

Sir: In an article in the *Engineering News-Record*, Sept. 1, 1938, p. 265, entitled "High Concrete Bridge for Low Cost", the author, E. A. White, makes the following statement, "Provision for expansion and contraction of a wholly hypothetical magnitude in concrete bridge decks has been responsible for large expenditures of money, the benefits of which may often be questioned." This amazing statement and others following it give the reader the impression that provision for expansion and contraction in bridges is, in general, unnecessary and unwarranted.

It should not be necessary to say that, except in very short spans, thermal deformation, the *bête noire* of the structural designer, cannot safely be so glibly dismissed. It is true that expansion bearing details have often been troublesome in the past. The logical remedy for this trouble, however, lies not in denying the necessity for expansion bearings but in improving their design. The development in the last few years of a number of novel and well conceived schemes for providing for expansion and contraction in bridges supports this contention. The fact that the magnitude of the thermal deformation is to some degree hypothetical is in itself sufficient reason for making ample provision for length changes; certainly it is little reason for making no provision at all.

It is a well known fact that temperature changes induce stress in any structure restrained by external forces. In a concrete bridge this fact is of particular significance. The nature of the material and the exposure of the structure to prolonged periods of high and low temperatures insure the formation of cracks with consequent disintegration of the concrete and corrosion of the steel. Actual cases of deterioration in concrete bridges due primarily to the lack of adequate provision for thermal deformation are numerous and have been largely responsible for the recent trend toward the development of more efficient expansion bearings.

In addition to cracking, spalling and local crushing in the deck, thermal deformation not infrequently produces undesirable and unsafe substructure conditions. Rocking of piers and abutments on the supporting soil or piles due to expansion and contraction of the deck tends to result in settlement or tilting with the possibility of ultimate failure of the structure.

In view of these facts it would seem that the "large expenditures of money" mentioned by Mr. White may, after all, be money wisely spent.

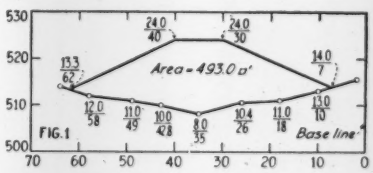
LESLIE R. SCHUREMAN
Princeton, N. J., Sept. 6, 1938

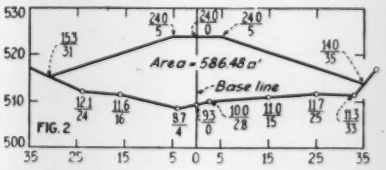
Earthwork Computation

Sir: Mr. Seal's article in the August 25, 1938, issue of *Engineering News-Record* should be of much interest to all computers, as it saves time and energy.

However, the writer has another setup for use on a Monroe Calculator, which requires less than half the machine work and consequently reduces chance for mistakes. This setup is outlined on the tables in the next column.

Note that the base line can be placed on either side or on the center line of a section. Also, no clearing of the dials, nor shifting of the division lever, is necessary. The plus bar is used to place the first elevation on the upper dial and then either the plus or minus bar is used, as required, to change the number on the upper dial. The method follows:





Area of Fig. No. 1

Elevation	Distance	Added Distance
14.0	7.0	17.0
13.0	10.0	28.0
11.0	18.0	44.0
10.4	26.0	61.0
08.0	35.0	77.8
10.0	42.8	91.8
11.0	49.0	107.0
12.0	58.0	120.0
13.3	62.0	102.0
24.0	40.0	70.0
24.0	30.0	37.0
14.0	7.0	

Double Area = 986.0 sq.ft.
True Area = $986.0 \times \frac{1}{2}$ = 493.0 sq.ft.

Area of Fig. No. 2

Elevation	Distance	Added Distance
24.0	0.0	0.0
9.3	0.0	4.0
8.7	4.0	20.0
11.6	16.0	40.0
12.1	24.0	55.0
15.3	31.0	36.0
24.0	5.0	5.0
24.0	0.0	

Double Area = 564.80 sq.ft.

Elevation	Distance	Added Distance
24.0	0.0	0.0
9.3	0.0	2.8
10.0	2.8	17.8
11.0	15.0	40.0
11.7	25.0	58.0
11.3	33.0	68.0
14.0	35.0	40.0
24.0	5.0	5.0
24.0	0.0	

Double Area = 608.16 sq.ft.

From Fig. 1, set up elevations and distances, proceeding in a clockwise direction. Then add the distances as shown.

With the keyboard clear, place 14.0 on the upper dial. Place 17.0 on the keyboard and change 14.0 on the upper dial to 13.0. Place 28.0 on the keyboard and change 13.0 to 11.0. Place 44.0 on the keyboard and change 11.0 to 10.4. Continue as above, until 37.0 has been used and 24.0 changed to 14.0. The answer on the lower dial, is the double area. For the true area divide by two.

Note when once the operation is begun, do not clear either dial.

From Fig. No. 2, set up elevations and distances as for Fig. No. 1, proceeding clockwise on the left-hand side of the base line and counter-clockwise on the right hand side.

Calculate both sides as in Fig. No. 1, add the two double areas obtained and divide by two for the true area.

Note that 9.3 is placed on the upper dial instead of 24.0, as the first distances add up to zero. Also, at the end of the operation, it is not necessary to use 5.0 on the keyboard, as 24.0 on the upper dial has already been reached.

EDWIN A. PEARSON
U. S. Engineer Office
New Boston, Ill., Aug. 31, 1938

Earthwork Computations

Sir: Both field and office methods in "True Areas on a Monroe Calculator" on page 245 of your issue of

(*Continued on adv. p. 32*)

ENGINEERING NEWS-RECORD

Copyright 1938, by McGraw-Hill Publishing Company, Inc.
Volume 121, Number 15

Editor, F. E. SCHMITT • *Editorial Staff*, V. T. BOUGHTON
C. S. HILL, N. A. BOWERS, W. C. BOWMAN, E. J. CLEARY
W. W. DE BERARD, H. W. RICHARDSON, R. B. COLBORN
Editorial Offices at 330 West 42nd Street, New York

OCTOBER 13, 1938

THE New England floods of last month in wrecking some of the new highway bridges built after the 1936 floods also washed away an old New England tradition, which in fact has rather wide acceptance outside of New England. The wrecked bridges had been built on old foundations in accordance with the traditional belief that nothing that is not completely worn out should be discarded. And these old foundations were in every case the cause of the loss of the new bridge. The temptation is strong to salvage old bridge foundations when a modern superstructure is built, particularly if the foundations have stood unharmed for forty or fifty years. That the temptation should be resisted is the lesson learned from the experience of New England towns and state highway departments. Old foundations are seldom deep enough; few are anchored in rock as most of them should be; almost none is worthy of safeguarding the investment that is required for a new superstructure. A good modern bridge on good modern foundations will resist almost any imaginable flood; dozens if not hundreds of such structures went through the recent floods unharmed. Placing a good modern bridge on old foundations is false economy; the recent flood proved this beyond any question.

Local Resources

MOST CHARACTERISTIC of the numerous differences between the New York World's Fair and the Golden Gate International Exposition is the use of steel as principal framework material in the former as against the wood framing that prevails on San Francisco's Treasure Island. The difference is a natural result of using the locally available material most suitable for the purpose. Subject to this difference, both undertakings have applied the respective materials of their choice with first-class skill and resourcefulness. The accomplishments of the San Francisco engineers, however, necessarily rested to a much greater extent on research and ingenuity for the development of the frame types and connections required by the unusual forms and dimensions of their buildings. As a result their structures will probably be found the more interesting subject of study by structural engineers. The resourcefulness of their design is suggestive, even inspirational, whether or not the structural types prove adaptable to application elsewhere.

"The Public Be Damned"

DEFINITE ASSURANCE that public works administrators are becoming conscious of the importance of good public relations was evident in the meeting of the American Public Works Association last week. Many of the speakers stressed the point that public servants have obligations that go beyond the rendering of proficient technical service. And it was clearly recognized that without citizen understanding and support no public works enterprise could be succesfully operated. Particularly significant were the remarks by Walter Millard, field secretary of the National Municipal League. The public may be hard to please, he said, but they have every right to be informed and to receive courteous attention when they seek information. Public officials were then reminded that people quite frequently are happier in the telling of a complaint than they are in the remedying of it. To merely give audience, therefore, to public demands would smooth the way to mutual understanding of public works problems and objectives. This perhaps is the first step in the pursuit of a constructive program of public relations. Bitter experience has shown the fallacy of "the public be damned" attitude.

Service Charge or Subsidy

CHAIRMAN FERGUSON of the Port of New York Authority, answering increasing demands for a reduction on tolls on the Holland Tunnel, has stated that the present rates on the Port Authority's tunnels and bridges are essential to their continued financial integrity and that there cannot be any revision downward for a number of years. Mr. Ferguson doubtless is correct in so far as the Port Authority's bridges are concerned, but the highly profitable Holland Tunnel is in a different class. It was not built by the authority, but by an interstate commission and under a definite understanding that the income would be used to pay off the bonds and that thereafter tolls would be reduced to the minimum required to operate the tunnel. Thus the spirit of the law appears to be on the side of those who call for a reduction of tolls though the system now in effect without doubt has materially aided in developing interstate highway connections at New York. So long as the excess income from one bridge or tunnel is used to finance another link in the highway system there can be little cause for complaints, but when the profits go to finance such operations as building large

freight terminals then what is ostensibly a service charge becomes a subsidy for some unrelated function, which is unsound public policy.

Worth Imitating

THE Arkansas highway department is offering seven courses of study to its employees to give them an unusual opportunity to increase their own knowledge and improve their chances for advancement and at the same time make themselves more useful to the department. Courses cover highway law, practical mathematics, statistical methods, cost accounting, business English, public speaking and care and operation of mechanical equipment. Able instructors have been picked. Other highway departments could well follow the example of Arkansas, as could city and state public works departments. In these days when so much thought is being given to public relations it is worth emphasizing that public relations like charity should begin at home. Make the most of your own employees, giving them the best possible breaks in the way of opportunity and compensation, and your public relations problems are more than half solved. Men who take pride in being part of any organization are its best ambassadors.

City Transit Difficulties

CITY TRANSIT matters come into focus by the effect of two recent news developments: decision to scrap the Sixth Avenue elevated railway in New York, and the financial report of the same city's municipal subway system, which reveals an insolvent, or better said, a highly tax-subsidized condition. These developments show the two principal means of urban rapid transit to be in serious difficulty.

The old-time elevated railways are on their way out after more than sixty years of useful service. Their noisy, street-darkening, blight-producing effects have gradually become more than people are willing to tolerate, and the agreement of the city's Board of Estimate and the Transit Commission to remove the Sixth Ave. line, first of the urban elevated lines to go, merely confirms the verdict of the man in the street. The rapid-transit agency that first made large metropolitan areas possible is no longer wanted. Chicago's frequent efforts to develop a satisfactory subway scheme to replace its elevated lines is supporting evidence of this fact.

At the same time the subway is proving itself an extravagant luxury. New York's Eight Avenue municipal system last year earned only enough to pay operating expenses—wages, power and maintenance—and fell far short of meeting fixed charges. Double the revenue actually received would be needed to cover capital charges as well as operating cost. Yet the line is carrying the major part of the traffic that is now available. Opening of the costly Sixth Ave. link will improve the service but will not add enough new traffic to anywhere near offset the added overhead cost.

The very vital subject of city mass transportation is thus in thoroughly unsatisfactory condition. A transportation device that meets minimum present-day requirements of acceptability at sufficiently low cost to be able to pay its way is not in existence. The elevated railway, cheap but obnoxious, is being discarded; the subway is unable to show self-supporting ability. Partly under the pressure of these facts, automobile and bus transportation is further congesting and slowing up our streets. Mass rapid transit in cities remains a major problem of the urban community.

Flood-Control Prospects

SPURRED into action by destruction wrought in the recent flood in New England, the federal government has laid down a flood-control program for that region which will cost $11,500,000. The work has been planned to avoid the controversial issue of control of power at flood-control reservoirs, no power development being called for at any of the proposed sites.

The flood-control act of 1938 authorized the federal government to go ahead with flood reservoirs without the state cooperation called for in the 1936 act. But it made ownership of land and flowage rights by the federal government mandatory; hence though the power question is not specifically present in the work now proposed the question of the constitutionality of this provision of the act may still be raised by Vermont or New Hampshire. The precedent of complete federal ownership and control, which the construction of the proposed dams will set, will be difficult to overcome when the power question is raised at some later date. There also is the added question, important for mountain states, of taking fertile valleys out of production in one state to form a reservoir to protect citizens in another state. This calls for the closest kind of cooperation between the states concerned.

The delay which put off start of reservoir construction until now, and the present threat of further delay due to the opposition of the governors of Vermont and New Hampshire, could all have been avoided through approval of the New England compacts last spring. At best the amount of power involved in most flood-control projects is small, certainly not worth the price of abandonment of all local participation.

★

THIS ISSUE—

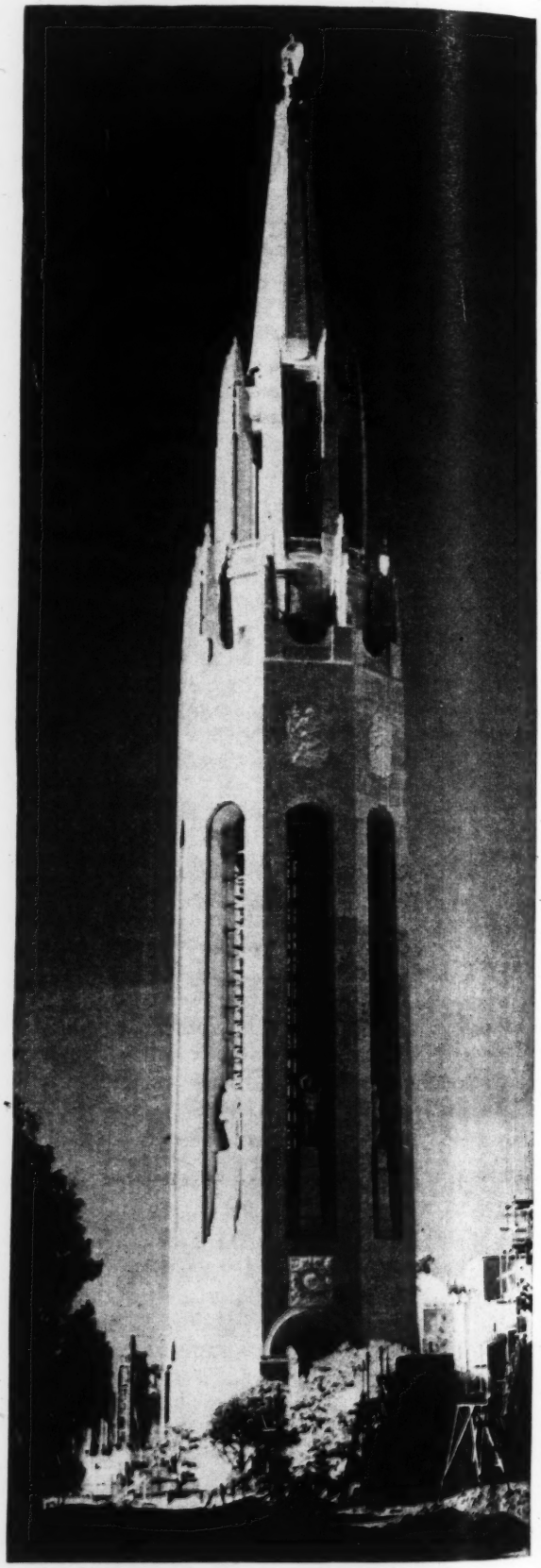
AN EXPOSITION is a demonstration of progress and of new developments. Buildings and grounds as well as exhibits should reflect and typify advance, making the event in all respects a milestone to sum up and record improvements and achievements of recent years.

Twenty-three years ago an international exposition was held in San Francisco. Next February another exposition will be ready for inspection, and thus a comparison is possible, in the same location and under comparable conditions, of almost a quarter-century of progress. Timber is the principal construction material for San Francisco's exposition buildings in 1939 as it was in 1915, but in the interim new methods have evolved, such as metal ring connectors, strap-and-pin joints, and the custom of (indeed, laws that require) making allowances in design for lateral forces to minimize earthquake risk. Examples of all these appear in the buildings on "Treasure Island."

In addition to recording progress, an exposition also should be a proving ground for new ideas, hence, such novelties as luminous plaster, fluorescent tubes for flood lighting, and new ideas in the use of color. Some of these will have to be seen to be fully appreciated. In many respects, however, data on design, unit costs and methods by which unusual problems were solved, can be recorded most effectively in print.

The object of this issue on the Golden Gate International Exposition is to make and preserve that record.

★



Tower of the Sun at Golden Gate Exposition

Exposition Celebrates Bridge Achievements

W. P. Day

Vice-President and Director of Works, Golden Gate International Exposition

A $20,000,000 undertaking, to celebrate completion of Golden Gate and Bay Bridges, developed out of an endeavor to provide a new air terminal for San Francisco

The Golden Gate International Exposition had its inception in the desire of a group of young men to establish an airport for San Francisco. The idea of initial, temporary use of the airport site for an exposition to celebrate the completion of two great bridges was no part of their scheme. But eventually it was such an exposition that made the airport possible.

It all started with a meeting in October, 1931, called by the aeronautics committee of the San Francisco Junior Chamber of Commerce, to discuss air terminals. Prominent citizens of the bay area attended, sites were suggested and, as an aftermath, a report prepared by the committee strongly recommended Yerba Buena Shoals, an area adjoining Yerba Buena Island, a naval station in San Francisco Bay. As the name indicates, the site was under water.

To celebrate the bridge

For a time no visible progress was made, but early in 1934 a bridge celebration committee was organized under the chairmanship of J. W. Mailliard, Jr., with whom an executive committee of 23 was soon at work. In February, 1934, a planning committee, organized some time earlier, issued a report recommending that an exposition be held to commemorate the completion of the San Francisco-Oakland Bay Bridge and the Golden Gate Bridge, and that the site be Yerba Buena Shoals.

In March, 1934, the writer was authorized to survey and report upon the comparative merits of sites available for such an exposition, and George W. Kelham, a well-known architect, was named to collaborate with him. The authorization carried no limitations whatever as to location. The resulting report, dated July 5, 1934, analyzed six possible sites, gave particular consideration to two and unequivocally recommended Yerba Buena Shoals as the location offering the greatest advantages. The general viewpoint was indicated by the following paragraph from the introduction to the report: "The selection of the most suitable site for an Exposition of this character must be controlled by those elements which offer the greatest probability of financial success, consistent with the achievement of the objects of the Exposition. For a given site, such elements are the cost of construction and operation thereof, accessibility, weather conditions, salvage possibilities or adaptability to permanent improvement, and its ability to create an advertising value purely by its setting or relationship to its surroundings. These offer a measuring stick as to its desirability."

In May, 1934, the Bridge Celebration Founding Committee formed a corporation with Leland W. Cutler as president and Athol McBean as chairman of the board of directors. This corporation proceeded to act on the location committee report. The proposed Yerba Buena Shoals site was ceded by the state of California to the city of San Francisco for development and use as a public airport, and the city authorized use of the site temporarily for an exposition, stipulating that the property be returned to the city when the exposition was over. Choice of the site was ratified by the voters at an election in 1935. The final move in the preliminary stage was the selection of the writer as the director of works in May, 1935, and authorization for him to prepare plans and specifications for reclaiming the underwater site. These plans had to be prepared in his private office, as there was no engineering organization for the Exposition at that time.

The necessity for raising funds presented an interesting problem. It was early recognized that, because of the prospective airport features, assistance might be obtained through the PWA and the WPA. An application for federal funds required that the sponsor be a political entity, and that a project be detailed as to all materials required as well as the number of men to be employed in each craft, the number of hours of employment of each, the total cost per man hour, etc.

Financing the exposition

To meet this situation the director of works prepared eight applications covering (1) reclamation and sea wall, (2) water supply, (3) roadways and bridges, (4) horticulture, (5) pavements, (6) ferry slips, (7) airport and other buildings, and (8) architectural and engineering design. As a result of these applications, in September, 1935, the WPA granted funds in the amount of $4,349,992. The sponsor's contribution was $1,087,499, making a total of $5,437,491. (San Francisco was the sponsor in name: the contribution was actually furnished by the Exposition company.) In addition, the PWA granted $1,894,274 as against a contribution of $2,315,335 by the company in behalf of the city. Thus the federal government advanced $6,244,266. This sum was later increased by supplemental applications to a total of $7,262,399.

An additional sum of $7,500,000 is being raised directly by the Exposition company through pledges from business and commercial interests in the Bay area. These pledges, payable in installments, are against non-interest revenue certificates. Whatever the ultimate surplus may be has been committed in settlement of these obligations pro rata. The major part of the remainder of the income

is figured against admissions, utilities, exhibit space and concessions.

Construction program

Shortly after the PWA grant was allowed, and before an engineering organization had been attempted, the Exposition company was notified that, to obtain the promised funds, construction would have to begin by Dec. 15, 1935. The Exposition had no stated program at that time, of course, but met the requirement by starting construction of an administration building on the mainland in San Francisco, and shortly thereafter, by beginning the construction of ferry slips at the Exposition site. At this time, there was no land near the slips, and justification for ferry slip construction was not apparent. However, this procedure was the only way to meet federal requirements that the work be prosecuted continuously, insofar as PWA funds were concerned. These enforced conditions, combined with other requirements in the federal applications, naturally determined the sequence of the entire construction operation (utilities, transportation facilities, water supply, and other features), which was laid out in general before a working organization was assembled.

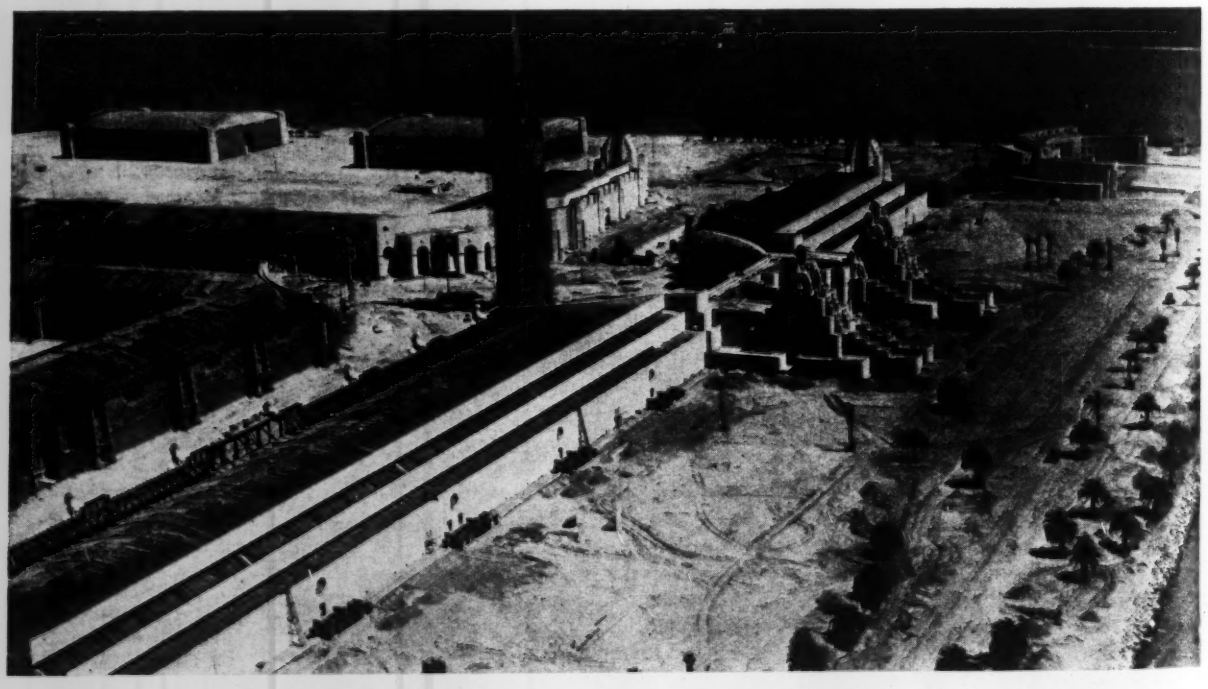
A conception of the problem confronting the Exposition's department of works may be had from the fact that requirements included construction of a city occupying some 400 acres in the middle of the bay, at a location where water depths ranged up to 26 ft. and averaged about 14 ft.

Creating the site and building the Exposition upon it called for a comprehensive staff whose assembly was left entirely to the director of works. He decided to divide the department into several divisions, each with its own chief, as follows: reclamation, structural engineering, architecture, water supply and sanitation, roads and bridges, electrical engineering, mechanical engineering, estimating, transportation, horticulture, construction, specifications, general office management. These divisions are responsible to the director of works for the physical creation of the Exposition.

Concurrently, an architectural commission, composed of five San Francisco architects, was selected, although all working drawings and specifications are prepared by the department of works. The rough preliminary sketches, prepared in accord with ideas of the commission, were estimated as to total cost, and modified by the director of works to meet the original assumptions. The rough estimates of gross construction cost indicated in the report of May, 1934, were somewhat increased, because of a rise in the material and labor market, but under rigid control, the estimates submitted in 1936 have not been exceeded. As this is written the work has progressed to such an extent that it is safe to say that the project will be completed within the budget.

The organization problem for the physical creation of an exposition is, perhaps, unlike that for any other type of construction. There are required men of exceptional ability to head the various divisions of the works department, gathered together for a comparatively short period of time, and working under high pressure. Throughout this undertaking effort has been made to establish a spirit of cooperation that is rather unusual in an organization designed to function at top speed for a limited period and thereafter to be disbanded.

The Exposition company will spend nearly $20,000,000, entirely apart from the cost of construction by participants, under supervision of the department of works, and it is to the engineers and architects of the several divisions that full credit should be given for the successful completion that is now in sight.



Getting the site ready for the February, 1939 opening of the Exposition. Yerba Buena Island in the background.

FIG. 1. DREDGES FINISH JOB AS BUILDING WORK BEGINS

An Island Built to Order

Golden Gate Exposition will occupy a 400-acre site over which water depths averaged 14 ft. before the 20,000,000-cu. yd. fill was made

WHEN Yerba Buena shoals in San Francisco Bay was selected as the site for the 1939 Exposition, the entire area was under water ranging up to 26 ft. deep. The nearest land was Yerba Buena Island, which is 1¾ mi. from San Francisco's Ferry Building, on the west side of the bay, and ¾ mi. from the extreme end of the Key System mole, which extends out from the east side of the bay. This island, which divides the Bay Bridge into east and west bay crossings, has an area of 150 acres, and rises to 325 ft. above sea level. Adjoining the island on the northwesterly side and separated from it by a 900-ft. channel lies Yerba Buena shoals, extending over some 735 acres. The portion of this submerged area filled in for the Exposition lies at its southern end, which is made accessible by a causeway from the island. The distance by automobile from Third and Market Sts. in San Francisco to the Exposition gates is 5 mi. via the Bay bridge.

At the outset it was recognized that reclamation of the site was in itself a project of major proportions. Original estimates indicated that some 19,000,000 cu.yd. of fill would be required, and ways and means of placing this material had to be found before definite steps could be taken toward the construction of the Exposition. A description of equipment and methods used in the major dredging operation, based on data from the U. S. Engineer Department, was published in *ENR* Mar. 18, 1937, p. 412. In the following is outlined that phase of the exposition company's undertaking that relates to providing a site.

In the early stages of the investigation, the question of what material would be found on the bay bottom at the site was of paramount importance.

Specific information on the following points was considered necessary:

1. Character of underlying materials.
2. Location of the most desirable borrow pit areas and detailed information about the material available there for fill.
3. Amount of settlement to be expected after completion of a fill made with available materials.
4. What remedial or preventative measures would be best if an appreciable amount of settlement was to be expected when loads were applied.
5. Amount of volumetric shrinkage to be expected in the fill if a seawall were constructed along three sides and filling operations were advanced progressively toward the open end.

Field investigations on (1), the character of underlying materials, began June 1, 1935 with 120 well-distributed borings extending down to depths as great as 60 ft. Of the one hundred samples of material taken from these borings, laboratory tests were made on sixteen.

The material underlying 75 per cent of the proposed fill area was found to be fine to coarse, loose sand, occasionally interbedded with soft sandy mud, mud with sand, sandy clay, or clay. These materials overlaid hard sand or firm clay at depths of 40 to 50 ft. below mean lower low water. In listing the various materials encountered the following classifications were made: "Sand" contains less than 10 per cent of silt and clay; "sand and mud" or "sand and clay" contain from 20 to 30 per cent of silt and clay; "mud with sand" 30 to 60 per cent silt and clay; and "clay" more than 60 per cent silt and clay. The percentages of mud and clay in the "sand and mud" and "sand and clay" materials were not found to be excessive, and are believed to occupy but slightly greater space than the voids in the sand aggregate. Hence the material was expected to develop sufficient internal friction to prevent plastic flow under load.

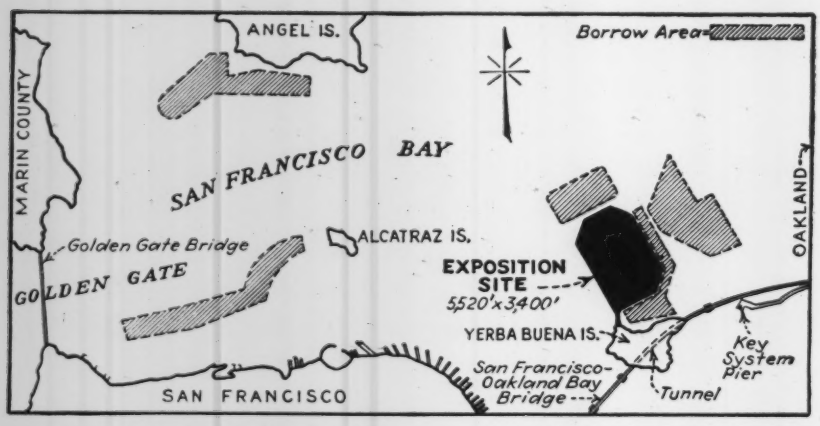


Fig. 2. Relation of exposition site to borrow pits used for its creation and to the two bridges whose completion the exposition celebrates.

The remaining 25 per cent of the fill area is underlain by mud, soft clay, soft mud and sand, and soft clay and sand. About 22 per cent of this soft area lies in the northerly end of the fill. The remainder lies at the southwest and southeast corners. Soft mud was found in the channel crossed by the causeway between the fill and Yerba Buena Island. The texture of the mud is rather fine: from 25 to 45 per cent of very fine and fine sand, 30 to 45 per cent silt, and 30 to 45 per cent clay. The soft condition suggested relatively high porosity. Such material, when loaded by the fill, was expected to give considerable consolidation as well as lateral displacement by plastic flow.

Recognized as among the important requirements for suitable dredger material were tendency to immediate consolidation, maximum density, and qualities making for large recovery with wastage of fines, ample quantity in borrow areas with a minimum of overburden, ease of excavation and short haul to the fill. The first three requirements, being controlled by the texture of the material, could be specified in terms of mechanical analyses. The others were controlled by selection of borrow areas. It was believed, also, that for immediate consolidation and maximum recovery, the criterion would be size of particle. Grading was believed to be unnecessary; the greater the percentage of large sizes of sand the more rapid would be the consolidation and the greater the recovery.

On the second item (borrow pit areas) exploration of the bay bottom by borings located suitable borrow pits close to the fill site. Later, under management of the Engineer Corps, U. S. Army, other areas were also dredged, as indicated in Fig. 2. The additional areas were used partly because dredging was needed there and partly because hopper dredges were available which could not work to good advantage in the limited areas between the pontooned pipe lines of the suction dredges.

As to (3), the amount of settlement to be expected, it was decided that subsequent to completion of the fill and under its own weight alone, settlement would be negligible in the sand area while in the mud area at the north end of the fill, it might exceed the rate of 1 ft. per year for several years. Settlement might also be expected in the mud areas at the causeway fill and at the southeast corner of the main fill.

Measures to control excessive settlement after construction (4) could be taken in the mud area, it was decided, as follows:

(a) Construct the fill progressively from south to north, giving opportunity for the sand fill to "wash out" soft shallow mud from the fill area.

(b) Excavate a trench to a depth of 25 ft. along the alignment of the north sea wall, backfilling it with sand to serve as a foundation for the rock wall. A similar procedure might be followed at the causeway and the southeast corner of the main fill.

Based on definite specifications as to materials and adherence to the sequence schedule, it was estimated that volumetric shrinkage (item 5) from cut to net fill at completion would be about 10 per cent in the sand area, and between 20 and 30 per cent in the mud area. This shrinkage, it was believed, would be the result of several causes, pricipally:

(a) Loss of fines by immediate transportation in suspension or subsequent displacement by the advancing sand fill after the fines were deposited upon the fill site as liquid mud.

(b) Loss of sand deposited upon the fill site through the action of wind and tidal currents.

(c) Consolidation of fill during construction.

(d) Consolidation, during construction, of material supporting the fill.

(e) Lateral displacement from the mud area during construction, produced by "pushing out" of soft shallow mud and plastic flow at greater depth.

Corps of Engineers takes charge

The shape of the site was determined by airport requirements and suggestions made by San Francisco's Public Utilities Commission as well as by the requirements of an ideal exposition site. Complete plans for reclamation, seawalls and causeway were prepared and submitted to the WPA Sept. 25, 1935. The application to the federal government, prepared by the director of works, indicated an estimated fill cost of $3,803,900. On Feb. 5, 1936, the Secretary of War approved a request from the WPA that the Corps of Engineers do the job.

When the Corps of Engineers took over the job some changes in plan were made. Plans and specifications prepared by the Exposition contemplated the construction of a sand fill around the perimeter of the site to El. 0, with a rock seawall constructed thereon to El. 14 ft. above M.L.L.W. Specifications for the fill itself and the type of construction on the seawall were modified by the Corps of Engineers to suit the assumption that the function of the rock was that of a retaining wall for the sand fill during construction only, and that after construction it would act as a riprap to protect the slopes against wave action. The outer slope of the rock fill was made 1:1¼, instead of 1:1½ as specified in the original plans.

At the outset the Corps of Engineers planned use of government plant in a limited way only. However, when no tenders were received from contractors in response to the first call for bids, plans were made to complete the fill with government plant plus whatever rented equipment was required. The rock work (282,814 tons) was later separately advertised and let. All the rock was handled by floating equipment; about seven-eighths of it was placed by clamshell

Fig. 3. Eleven hopper and suction dredges (only four are here shown) delivered material to the fill at the rate of 3,500,000 cu. yd. per month.

and skips and the remainder from side-dump barges.

When the initial hydraulic fill underlying the rock seawall was brought up to 6 ft. below M.L.L.W., the first lift of class *C* rock was brought up to El. 2 to hold the backfill and protect it against wave action; the second stage of sand backfill was placed against this first rock lift. The second lift of rock wall was carried up to El. 6 and backfilled by the third stage of sand fill or by material placed by clamshell dredger. The objective was to provide supporting material behind the rock wall as fast as the rock placement was raised above tide water. The final lift of rock brought the wall to its completed elevation of 14 ft. (The top elevation of fill over the island is El. 13.)

Class *A* rock contained pieces weighing not less than 500 lb. nor more than three tons each, with not less than 50 per cent weighing one ton or more. Contract price was $1.75 per ton. Class *B* rock was quarry-run, ranging from fines to pieces weighing about 1,000 lb. each, with a further requirement that not less than 50 per cent should weigh 200 lb. or more each, and that not more than 20 per cent might be pieces weighing as little as 3 lb. Contract price was $1.25. Class *C* rock was quarry-run, ranging from fines to pieces weighing about 400 lb. each, with not less than 50 per cent weighing 150 lb. each, and not more than 25 per cent weighing 3 lb. or less. Contract price was $1.10.

The initial rate of delivery called for was 25,000 tons per month, but this subsequently was raised to 40,000 tons per month. While the job was at its peak the contractors employed 18 rock barges, 5 derrick barges and 6 tugboats; maximum delivery rate reached 46,000 tons of rock per month.

The fleet of dredges used for delivering materials to the fill was said to be one of the largest and most comprehensive assemblies of its kind ever brought together. As the fill progressed, the mud conditions predicted by the exposition company were encountered at the northeast corner of the fill, and it was decided to modify the side slopes of this area, to deposit a counterweight of sand beyond the slope, to trench along the line of the wall for a width of 400 ft., and to a depth varying from 20 to 30 ft. into the mud bottom. This trench was backfilled with heavy sand, weighing, in some instances, as much as 138 lb. per cu.ft.

The Exposition's original estimate for the fill was 19,000,000 cu.yd. in place. The estimate reported by the Corps of Engineers was 21,000,000 cu.yd. of finished fill, entailing the dredging of some 29,000,000 cu.yd. in the cut. Retention for the entire operation was about 70 per cent.

The average cost of handling the 29,000,000 cu.yd. in the cut was slightly more than 11c. per cu.yd. or about 16c. per cu.yd. of fill in place. The work was completed on Aug. 24, 1937, just within the original estimate of $3,803,900.

As was expected, uneven mass settlement took place over the area. In the initial stages of filling operations, the southwesterly portion of the fill had the least settlement. During 1937, it settled at the rate of 0.086 ft. per month. Later, the rate of settlement in this area reduced to about 0.05 ft. per month. In the northwest area, a softer material of clay and sand was pumped into place. For the first seven months of 1937,

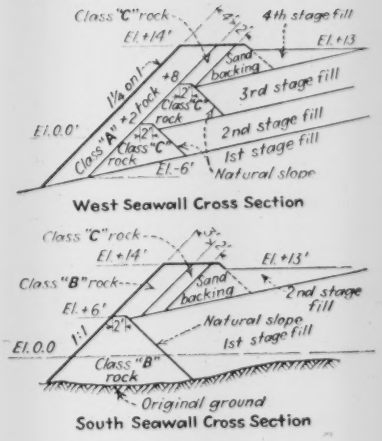


Fig. 4. Typical cross-sections of rock embankments that retain the dredged fill.

the average rate of settlement here was 0.13 ft. per month; this also decreased and the later average was 0.044 ft. per month. In the northeast area of the fill the average monthly rate of settlement a year ago was 0.13 ft.; this average has decreased to 0.064 ft. per month. In the initial stages of the filling operations in the southeast area, the settlement rate was 0.15 ft. per month and this decreased to 0.04 ft. per month.

Credit has been given in the foregoing to the Corps of Engineers, U. S. Army, for the field execution of this project. James J. Walsh, later chief of the division of reclamation for the Exposition, acted as consultant in the preparation of the original plans, and as observer for the Exposition company during the execution of the project. Charles H. Lee, later chief, division of water supply and sanitation, prepared reports and made soil tests in connection with the preparatory investigations.

Draining and Leaching Treasure Island

CHARLES H. LEE

Chief, Division of Water Supply and Sanitation, Golden Gate International Exposition

Fill of salty soil was made suitable for trees and gardens by pumping from wells and leaching with fresh water

UNUSUAL hydraulic and soil conditioning problems had to be solved before any planting could begin on Treasure Island. The fill, as described in the previous article, was made with material dredged from the bay bottom and delivered by salt water suspension.

Naturally the fill remained saturated with salt; even above the water table the soil retained saline and moisture content far exceeding the tolerance of the vegetation which it was proposed to plant. This was the situation in August, 1937, when filling was finished.

To make the horticultural work possible a program of soil drainage was employed which prepared the soil for planting in a period of about four months. It comprised (1) lowering the water table by pumping, and (2) leaching. Part of the soil, containing clay balls, retained chlorine tenaciously even after leaching, and here soil replacement was used successfully. Methods, conditions, rates of progress and results are given in the following.

After filling was finished

The fill is composed chiefly of layered dredger-sand, with occasional clay balls in a sand matrix, and local areas of fine bedded clay with black silt. Specific gravity varies from 2.72 to 2.76; porosity ranges from 41.9 per cent by volume for sand, to 62.2 per cent for clay; the dry weight ranges from 64.2 lb. per cu. ft. for clay to 99.9 lb. for sand. The clay was practically impermeable; a silty fine sand, when undisturbed, transmitted 43.91 gal. per sq. ft. per 24 hr. at 100 per cent gradient and 60 deg. F.; medium sand transmitted 283.4 gal. under the same test conditions. Chlorine content varied from 5,000 p.p.m. of dry weight of soil to as little as 115 p.p.m.

In June of 1937, with dredging essentially completed and surface of the fill at El. +13, the water table was highest near the center of the fill (El. +12 to +13), sloping thence in all directions toward the seawall, where it was about El. +6.0. There was, thus, a "dome" of salt water within the fill.

The slope of this salt water dome was steepest in the first 800 ft. back from the seawall, where the gradient was 7.5 ft. per 1,000. In November, five months later, as the result of natural drainage only, the crest of the dome had dropped slightly, the slopes were flatter, and at the perimeter of the older portion of the fill the water stood between mean high tide (El. +5.54) and mean tide (El. +3.30). Water level in test holes had lowered 2 ft. to 4.5 ft., although accumulations from rainfall had caused temporary rises ranging from a few inches to 3 ft. Losses by evaporation were negligible. It was evident that years would elapse before the water table reached equilibrium.

Lowering the water table

Field planting of trees had to begin May 15, 1938, to meet the construction schedule; therefore rapid artificial drainage and soil-conditioning were necessary. The controlling factor in adjustment of the water table was the large trees, to be distributed generally over the fill, which were to be planted in root-boxes with bottoms at El. +8. To keep the tree alive the bottom of the root-box must be kept above the water table and also above the capillary fringe, and the chlorine content of the adjacent soil should not exceed 100 p.p.m.

It was concluded that (1) the general water table could not be drawn down below El. +5 without danger of salt-water intrusion through the seawall, and (2) the highest level at which salt water could be permitted, if the tree roots were to be kept above the capillary fringe, was El. +6.0. It was clear also that, if the water table was to be held down to El. +5.0, artificial drainage would have to be more or less continuous throughout the life of the Exposition. Water table contours as of Jan. 10, 1938, indicated a total salt-water volume of 240 acre-ft. above El. +5.0 in the planting areas of the fill. This water, plus any accretions, had to be removed in a period of about four months.

Tests of draining methods

To find the best drainage procedure, various methods were tried. Tile drainage was early dismissed because of high cost and insufficient gradient for gravity operation. To test the possibilities of open drains nearly 2,000,000 gal. was pumped from a ditch 740 ft. long, 6 ft. wide at bottom, 6 ft. deep at ends and 8.3 ft. deep at the central sump. Effects of this pumping extended 500 to 700 ft. either side of the ditch, and the slope of the adjacent water table stabilized at 0.8 to 1.3 ft. per 100. Equating the volume pumped and volume of sand drained showed the specific yield of the fill to be 23 per cent. Decreasing yield indicated a low velocity of groundwater through the fill; this varied from 0.75 ft. to 9.10 ft. per year, depending upon permeability and gradient.

Tests also were made with various types of wells, 22 to 25 ft. deep, and also with well points, for which typical results are shown in the table. During a 30-day test of a 30-in. gravel envelope casing well, water levels in adjacent lines of test holes showed, for a 13.7-ft. well drawdown, a drop of 3.6 ft. at 50-ft.; 2.7 ft. at 100 ft.; and 1.8 ft. at 200 ft. The

radius of the circle of influence was about 500 ft. For greatest efficiency, the tests showed cased wells should be spaced at least 200 ft., and well points at least 100 ft.

Comparison of results

These comparative tests showed the cost of the drain ditch per acre drained to be more than six times that of wells, with 10 per cent less yield, lower efficiency, less flexibility, longer construction time, and obstruction of valuable ground space. As between wellpoints and cased wells the former were chosen because of their flexibility and quick installation.

TYPICAL YIELDS OF WELLS AND WELLPOINTS

Item	Wells			Wellpoints		
Casing or Pipe						
Inside diameter	6 in.	4 in.	4 in.	2 in.	1¼ in.	1¼ in.
Length	22 ft.	22 ft.	22 ft.	22 ft.	24 ft.	24 ft.
Perforations						
Size	2" x ¼" vert. cuts	2" x ¼" vert. cuts	2" x ¼" vert. cuts	60 mesh screen	.025" annular slots	.012" annular slots
Length	16 ft.	4 ft.	4 ft.	36 in.	17¼ in.	35 in.
Envelope						
Material	Concrete aggregate	Natural washed gravel	Natural washed gravel	Concrete aggregate	Coarse sand*	Coarse sand
Diameter	30 in.	20 in.	14 in. enlarged to 33 in. for bottom 7 ft.	30 in.	10 in.	10 in.
Depth	23 ft.	23 ft.	23 ft.	23 ft.	25 ft.	25 ft.
Fill Material	Fine sand	Fine sand	Fine sand	Fine sand	Clayey fine sand	Fine sand
Initial Yield	30 g.p.m.	20 g.p.m.	30 g.p.m.	0*	5 g.p.m	11 g.p.m.

* Screen openings closed by sticky jel caused by excessive deflocculation of clay by salt water.

Pumping with wellpoints

Volume pumping began Jan. 11, 1938, and ceased when desirable water-table levels were reached late in May. The heavy-duty wellpoints used had inside diameters of 1¼ in., were 48 in. in length, and had continuous annular slots 0.012 in. wide. These were connected to 1¼-in. risers, and were put down to the bottom of 10-in. holes previously jetted 25 ft. into the fill and then, after placement of wellpoints, backfilled with coarse sand to form a collecting envelope. Wells were grouped in units of 12 around a central pump; initially the wells were spaced 60 ft. apart in an endeavor to save space, but later it was found possible to increase the spacing to 75, 80, and in some cases 100 ft.; the latter is the spacing shown by the tests to be desirable.

Suction headers consisting of 1½-, 2- and 3-in pipe were laid on the ground in "*H*" or double "*H*" form with the pump in the center. Discharge was through short horizontal runs of 3-in. pipe to the nearest storm sewer manhole. The total number of pumping units was 40, with a maximum of 24 operating at a time, and an average of 20. Pumps were operated continuously until water levels were drawn down to the point of surging or beaking suction.

Motor-driven pumps used

Heavy-duty self-priming pumps were used, in 2- and 3-in. sizes, driven by 3- and 7½-hp. horizontal direct-connected electric motors. Rated pump capacities for low discharge heads were 180 and 400 g.p.m. Actual maximum discharge rates were 125 and 250 g.p.m. The average vacuum carried was 21 to 23 in., with a maximum of 29 in. Power consumption was about 240 kw.-hr. per acre-ft. pumped.

Total water pumped was 566 acre-ft.: the initial 240 acre-ft. of salt water plus 326 acre-ft. of absorbed rainfall. The yield of individual wellpoints varied from 5 to 25 g.p.m.; averaged 4.7 g.p.m.

The water level over the pumping area was reduced from a maximum of El. +12.0 to an average of below El. +5.0, with large areas below El. +3.0. No effort was made to reduce the water table beneath the parking area at the north end of the fill, in a small part of which it still remains at El. +10.0.

Individual pumping units effectively lowered the water table for horizontal distances of 200 to 300 ft., with minor effects as far as 600 ft. Water level under interior courts, between main palaces, was pumped down to El. +5.0 by units spaced 800 ft. apart, on opposite sides of main buildings.

Effect of leaching

Drainage of the saturated fill automatically reduced the chlorine content from a maximum of 5,000 p.p.m. to about 1,000 p.p.m. With respect to the condition early in January, 1938, salinity content in the north end of the island ranged from 1,000 to 5,000 p.p.m. Abnormal rainfall, exceeding 16 in. between Jan. 14 and March 22, 1938, reduced the chlorine in sandy, fully drained areas to less than 100 p.p.m. Such areas, at least 70 per cent of the total, were then ready for planting. Salinity remained high in clay ball areas—from 500 to 2,500 p.p.m. of chlorine, with surounding sand showing as much as 500 p.p.m. In sandy soil blanketed by bedded clay the chlorine varied from 860 to 3,500 p.p.m.

Clay areas sprinkled

To supplement the leaching that resulted from rainfall, an additional 12 in. of water was applied to clay areas by revolving sprinkler heads at the rate of 1/3-in. per hour. This rate was slightly less than the maximum absorption by sand, thus avoiding surface flooding which would float the fines and seal the surface. Application was made in 8- and 16-hr. periods with similar intervals between.

Special treatment in clay ball areas included removal of all clay from the backfill for a distance of 2 ft. around and beneath each tree-box and replacement of this clay with a screened backfill containing 1 lb. of gypsum per cubic ft. to neutralize salinity. Planting began May 15, on schedule.

Execution of drainage and leaching was in charge of H. C. Vensano, chief, division of construction; Ned D. Baker was assistant in immediate charge. The writer was in charge of investigations and outlining of plans for drainage, leaching and chemical treatment of the soil. Laboratory experimental work was carried on at Pacific Hydrologic Laboratory. Valuable advice on leaching problems was furnished by J. C. Martin, division of plant nutrition, department of agriculture, University of California.

FIG. I. BUILDINGS, AT LEFT, 80 FT. HIGH, PROTECT THE GROUNDS FROM PREVAILING WINDS

Planning Buildings and Grounds

Buildings, showing Maya influence and using new schemes for luminosity by night, serve as windbreaks for extensive gardens in a colorful setting

THE SITE of the Golden Gate International Exposition is almost in the middle of San Francisco Bay and hence offers unique opportunity for developing the charm and beauty of natural surroundings. The water foreground and the background of hills in San Francisco, Alameda and Marin counties afford a rare setting which can be seen to advantage from main travel routes by water, rail and air. How these natural advantages were utilized and how ingenious methods made adequate space available with suitable wind protection is outlined in the following.

Prevailing winds in San Francisco come from the west and southwest nearly 90 per cent of the time. Average velocity during the summer for the past several years has been a little less than 8 m.p.h., and the winter average has been about 6 m.p.h. The fact that the wind comes chiefly from the ocean side made it possible to group and to design buildings for maximum wind protection.

Records over a 45-yr. period at the government lighthouse station on Yerba Buena Island, adjacent to the site, show an average of 142 hr. of fog per year, with practically no fog in March or April, and none at all in May, June, July and August. At least 60 per cent of the fog occurs in November, December and January. Fog conditions on the site of the exposition are essentially different, according to these records, from other points about the bay because it is south and east of the routes usually taken by sea fog and tule fog, and it is free from fogs during the summer when the city has its worst sea fogs. In contrast with the Exposition site, records for San Francisco indicate that sea fogs shut out about 50 per cent of June, July and August sunlight.

To the architectural commission, appointed by the Exposition company, and composed of five San Francisco architects, there was submitted the problem of determining the style of architecture and a building group plan, controlled only by the assumptions necessarily made by the director of works in the application for federal government funds. Perhaps for the first time in the history of expositions, architects were given a site whose

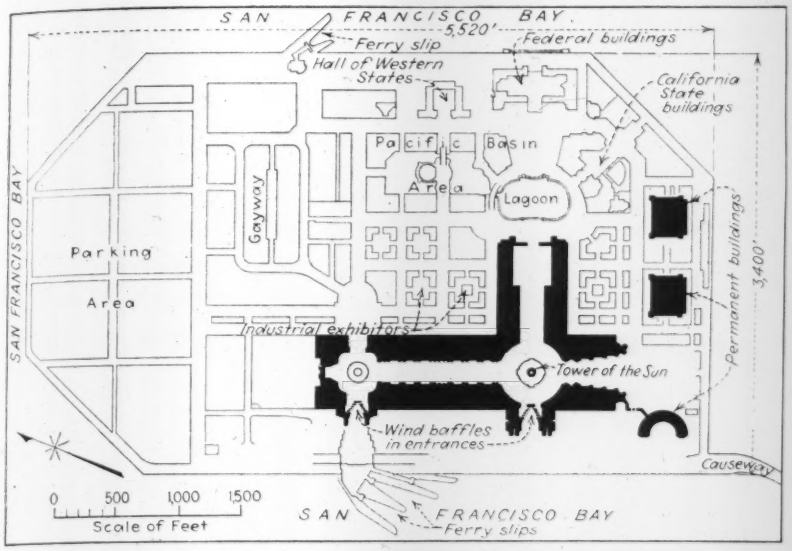


Fig. 2. Plan of exposition grounds. Main exhibit palaces are shown solid and the three airport buildings are at extreme right.

shape and size were made to order for their purpose.

Architectural considerations

This commission, in search of new sources of inspiration, studied the Panama Pacific International Exposition of 1915, with its rather strict adherence to established architectural styles, and the more recent Chicago exposition which attempted something decidedly modern. Architects who had worked on both these previous events served on the commission for San Francisco's 1939 exposition.

As to the selection of an architectural theme, a member of the Exposition staff outlines it as follows: "Since the Exposition is to be a Pageant of the Pacific, it was natural that the architects should select a structural style set by a race that ran a course and died, leaving remains of a forgotten people whose noble temples suggest a high civilization. The Maya civilization and architecture of old Mexico has been little known in the United States, but more popular attention to archeology and particularly the activities of the Carnegie Institute have of late focused widespread interest upon it.

"Although Maya architecture has quite frequently been embodied in the design of modern structures, compositions and general concepts usually have followed recognized classics. In these Exposition structures the treatment is adjusted to a modern trend with a mingling of Oriental, Cambodian and Maya styles which should lead to lasting memories of composition beauty. A major objective was the creation of a practical and at the same time dramatic presentation wholly unlike any heretofore attempted."

In the layout of the grounds there is no single focal point to confuse traffic; the effort, rather, has been to achieve an even distribution. This applies primarily to structures erected with Exposition company funds, but even for the structures to be designed and built by participants the areas have been laid out with wide tree-lined avenues and streets and the area is subdivided into blocks just as in a city of ideal, advance planning.

Since wind comes from only one direction so much of the time, it was decided to provide wind protection by locating continuous buildings of considerable height along the western boundary of the grounds. Under such an arrangement shelter would be provided for the entire area except the space devoted to automobile parking. Again, this plan made the southerly end of the fill a particularly secluded area partly by reason of the building arrangement and partly because of nearby Yerba Buena Island. This area, therefore, will lend itself well to aquatic sports and other uses of the lagoon to be formed between the site and Yerba Buena Island. Fortunately, nothing in the original assumptions upon which all the preliminary steps in the construction had been based, conflicted with this general scheme of arrangement.

Although design and construction of the participants' buildings are under the control of the department of works, wide latitude is permitted in architectural design. The result has been the creation of a group plan of unusual architectural unity. It is almost impossible to segregate the twelve principal exhibit palaces into individual units. Unbroken walls and parapets extend in two directions, rising to tremendous gateways and curving around courts and gardens in

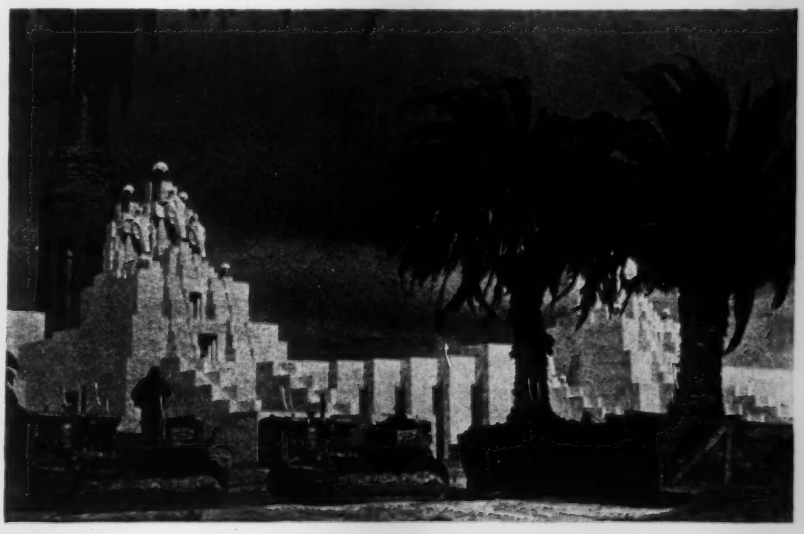


Fig. 3. Against a background of Maya architecture, two of the thousands of trees required for landscaping are sledded across the island by tractors.

an area more than half a mile long by a third of a mile wide.

The first rough plans were developed into a scale model with which it was determined by experiment that walls about 80 ft. high would divert wind to best advantage and give a comparatively sheltered area on the lee side. Manifestly a wall this high could not be justified, economically, unless it also served another purpose, i.e., was part of a building. It was this consideration which led to the great height of the buildings with their setback walls and their great unobstructed interior spans.

Distinctive features

The principal structures erected by the company itself are two large hangars, an airport terminal building, a series of connected exhibit palaces covering more than 1,000,000 sq.ft., a central tower, a Pacific basin area (composed of a central unit and surounded by buildings representative of countries on the Pacific Ocean), a western states building, a fine arts palace, ferry slips, warehouses, police and fire houses, roads, bridges, etc., together with lagoons, fountains and pools. Some idea of size is indicated by the following:

Pavements (including parking area)	8,920,000 sq.ft.
Excavation (after dredging)	450,000 cu.yd.
Garden areas	2,666,000 sq.ft.
Lagoon areas	365,000 sq.ft.
Fresh water in lagoons	7,000,000 gal.
Total length of utility lines	35 miles

The general design was partly controlled by the necessity for the erection of hangars and an airport terminal building for a permanent airport for the city of San Francisco. The two hangars are duplicates in design, and each has outside dimensions of 287½x335 ft. (*ENR*, Sept. 16, 1937, p. 478). The total cost of these two structures, of reinforced concrete and structural steel, exclusive of outside and inside finish and doors, was $725,000. Their location is at the southerly end of the fill, convenient to the nearby lagoon that will be used by seaplanes. Hangar construction was started just as soon as the fill at the southerly end was completed, not from choice, but because of the necessity for continuous construction to comply with PWA requirements.

The airport terminal building, designed after careful investigation of principal terminals of the United States, is of reinforced concrete on a pile foundation. It is semi-circular and its floor plan contains 160,000 sq.ft. Its total cost was about $850,000. This building and the hangar buildings are finished with a dash coat of cement plaster to match as closely as possible the exterior finish of the temporary exhibition structures.

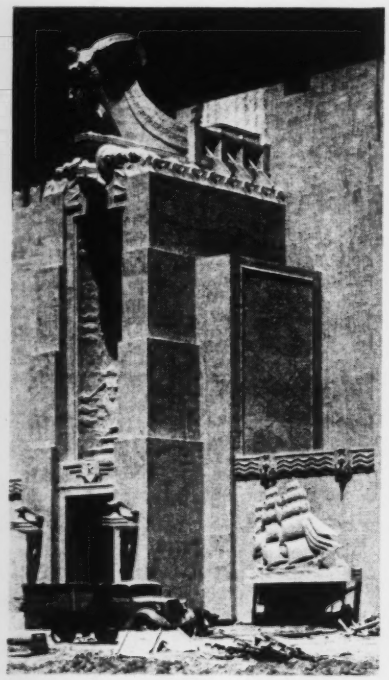


Fig. 4. Sculptural details in the Court of the Seven Seas.

A feature representative of the theme "Pageant of the Pacific" is the area devoted to the Pacific basin. This area which includes about 20 acres, will consist of a central building to be known as "Pacific House" and a series of structures representative of Pacific basin countries. Two larger lagoons will divide the area, and the horticulture will be typical of the countries represented.

Color and illumination

The walls of the main buildings are finished with a gypsum plaster of light ivory color and a lasting, luminous quality. This effect was achieved by pressing a mica product into the plastered surfaces. The mica used had first been heated to a high degree so that it became flaky and the laminations tended to separate. The result is a breaking up of the wall surfaces into innumerable small holes which reflect light in a way impossible with a flat wall surface. The object of this treatment is to cause the walls to scintillate in a novel and interesting way. Preliminary tests indicate that the effect will be particularly striking under the floodlighting scheme planned for night illumination.

The gypsum plaster mixture was 2½ cu.ft. of light colored, dry sand to each sack of fibred, hardwall plaster. Color pigment was added at the rate of about 8 oz. per 100 lb. of plaster. No wire mesh was used; instead the plaster was applied in thicknesses of ⅜ in. to ½ in. on 1x6-in. sheathing boards specially grooved to provide bond. The average cost of the plaster was 56c. per sq.yd. without scaffolding, and scaffolding cost 25c. per sq.yd. The mica compound cost 82c. per sack of 40 lb. As one sack was enough for about 40 sq.yd. this feature added about 2c. per sq.yd. to the cost. Thus total cost for the plaster was 83c. per sq.yd.

The standard palette of Exposition colors includes 19 variations. All main or palace buildings and the outside of exhibit buildings will conform to this standard color scheme. Inside exhibits and concessions in the palaces will follow the same color schedule except where departures therefrom are justified by nationally known trademarks. Fundamental color schemes by day will be in half tones of ivory, gold, brown, and shades of blue.

For night color effects the floodlighting, which will be used on the walls of all buildings except in the concession area, will employ a new light source known as florescent tubes. These tubes will appear here in their first large installation for commercial purposes. The new lamps make possible the graduation of colors to a higher degree than ever before attained, and color lighting is to be handled as are paints by an artist. The new lights are claimed to be four times as efficient as high grade incandescent lamps.

Horticultural development

Although the $2,000,000 horticultural development has been in course of preparation for nearly 3 years, not until recently did trees begin to move

to the site. Nothing could be planted of course until after the extraction of some 650 acre-ft. of salt water from the fill, as described in the previous article.

Loam, varying in depth from 8 in. to 2 ft., was used to cover those portions of the site where gardens are to be planted. The loam was obtained from islands at the mouth of the San Joaquin River, brought to the site by barges, and thence hauled by truck to destination. About 100,000 cu.yd. of loam is being thus delivered and placed at a cost of $1.35 per cu.yd.

Some 3,300 large trees were obtained from various counties around the bay. Trees 60 or 70 ft. high and weighing 50 tons were boxed and moved to the site.

The type of floor used in the main palaces is a 1½x6-in. "*C* grade" matched flooring on joists, beams and posts. The cost was about 24c. per sq.ft. Columns of the exterior walls carrying the roof trusses are supported on piles (not included in the above cost) but floors are built directly on the fill surface.

Roofing costs

All palaces have a two-ply roofing which cost 5c. per sq. ft. The cost of finished roofs supported on long span arches was about 66c. per sq.ft. exclusive of any part of wall costs. In limited areas, roofs are supported on posts, and here the cost was about 50c. per sq.ft. including roofing. These prices were considerably reduced for roofs not more than 20 ft. above ground; for these the price was not more than 30c. per sq.ft. Architectural staff, without sculpture, cost about $3 per sq.ft., and sculptured staff, likewise without sculpture, was about double, or $6 per sq.ft.

Pile lengths varied from 45 ft. driven without jets, to a maximum of 90 ft. driven with jets. The 45-ft. piles cost about $30 per pile in place. In 65 to 70-ft. lengths, driven with jets, the cost varied from $38 to $46 per pile; 90-ft. piles, jetted, cost about $49.50 each.

The architectural commission originally selected comprised George W. Kelham, now deceased, Arthur Brown, Jr., Lewis P. Hobart, Timothy Pflueger, William G. Merchant and Ernest Weihe. W. P. Day, director of works, is an ex-officio member of the commission. After Mr. Kelham's death, Edward L. Frick, not a member of the commission, was chosen to head the division of architecture. Jesse Stanton is director of color.

Timber Plays a Leading Role

Wood was the logical material and, in using it to house a million square feet of floor space, useful new ideas and methods were developed

More than a million square feet of floor area had to be housed by the Exposition company in structures that would be in use less than a year. There were permanent structures too, of course, such as the two hangars and the air terminal building, totaling 350,000 sq.ft. of floor space. The latter were built of reinforced concrete and structural steel but for the temporary structures numerous advantages favored timber. Some of these were lower first cost, speed of erection, ease in removal after the Exposition and salvage value. There was also the consideration that lumber is a local product obtainable from nearby mills.

Timber has been used almost exclusively in twelve exhibit palaces, the 400-ft. Tower of the Sun (a steel frame clothed in timber) and necessary adjuncts such as warehouses, police and fire stations, ferry terminal buildings, gateways, pools, grandstands, flag standards, subways, bridges and Pacific basin buildings. Altogether, in the buildings, other than those put up by individual exhibitors, about 27,000,000 ft.b.m. of timber (exclusive of wharves) was required. A large part of this was

Fig. 1. Typical exhibit palace roofed with three-hinged timber arches of 200-ft. span and enclosed in prefabricated roof and wall panels.

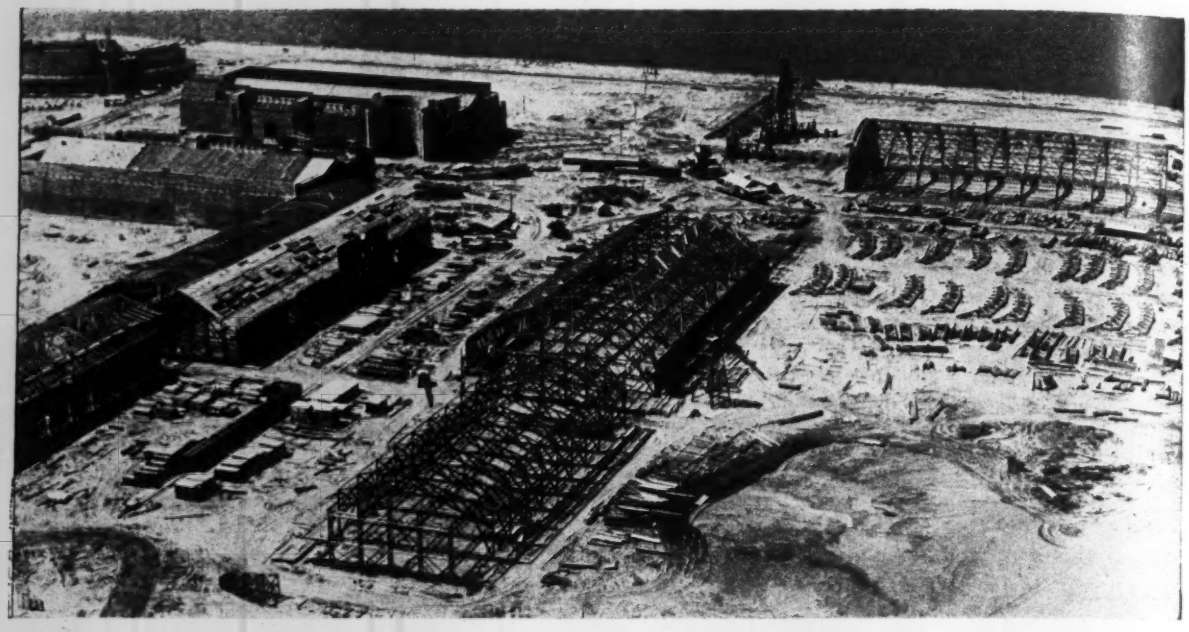


Fig. 2. Some 27,000,000 ft. b.m. of timber was used in construction of principal exposition buildings, shown here in early stages. Note halves of 200-ft. span roof trusses on ground at right.

Douglas fir, although for certain uses redwood and hemlock were employed.

In addition to the normal vertical loading, all structures were designed for a wind load of 15 lb. per sq.ft. for the first 60 ft. of height, and 20 lb. per sq.ft. above that height. For the hangars and the airport terminal building (permanent structures) a seismic factor of 0.08 *g*, was assumed. In all timber structures adequate resistance to lateral forces was afforded by a structural design worked out for wind loads only. For figuring a combination of vertical and seismic loads, the usual working stresses were increased from one-third to one-half, depending upon the particular use and type of the structure.

To provide wind load resistance, extensive use was made of diagonal sheathing as diaphragms. As an example, the huge Gates of the Pacific, 60 ft. in height, and serrated in plan, were framed with studs and diagonal sheathing only. In the lower portions, where large openings occur, rigid frame bent action was obtained by the use of two layers of diagonal sheathing and cut-in chords taking the tension and compressive stresses.

Practically all of the exhibit palaces were designed for a live load of 100 lb. per sq.ft. The unit stress for timbers and joint details on floors was 1,800 lb. per sq.in. for No. 1 common lumber, and 1,600 lb. per sq.in. for roof loads.

Pile foundations

The exhibit palaces are supported on wooden piles about 65 ft. long loaded with a maximum vertical downward load of 30 tons per pile, a maximum uplift of 7½ tons and a maximum horizontal load of 2½ tons per pile. Under the central tower, 90-ft. piles were used, and there was no uplift on the piles from a 20-lb. wind. In many instances anchorage to the ground against wind loads was obtained by dependence upon piles in both tension and shear. The roof arches, together with the exterior walls and architectural ornamentation, are supported on concrete and timber foundations resting on the piles, but the floor construction is supported by separate footings of timber resting directly on the ground. Continuous slip joint construction between the floor and that part of the structure on piles provides for differential settlements. Support of roof arches and exterior walls on piles was justified, it was believed, to provide for expected settlement of the fill that might seriously crack exterior plaster if piles were not used. The floor, on the other hand, might be raised readily without serious damage in the event of noticeable change in level. As this was written, after the floors and a large part of the exterior plastering had been in place for a number of months, there was no indication of failure through unequal settlement. The only settlement that required remedy was in one of the hangars, where elevations of the footings were modified to conform with unequal subsidence in the perimeter of the building.

The possibility of mass subsidence caused by consolidation of the fill itself and by the pressing of water from material beneath the fill influenced in large part the general scheme of structural framing. The opinion, borne out by actual measurements on the completed structures, was that the mass subsidence for buildings occupying small areas would be practically uniform over the area of the structure and need not cause alarm. It was recognized, however, that in structures extending over large areas the underlying materials would be so diversified as to warrant the expectation of unequal settlements within the area of an individual building. For this reason, flexible and statically determinate systems were used wherever possible, with the satisfactory results mentioned above. The typical exhibit palaces are 200 ft. wide and 887 ft. long. A series of three-hinged timber arches was

used, spanning the full width of 200 ft. and spaced 41 ft. center to center; in the center of the building the clear distance from the floor to the bottom of the arch is 68 ft.

Structural features

The walls of the palace buildings vary from 65 to 85 ft. in height, with a series of setbacks for architectural effect and for concealing floodlighting units. It was the setback wall as much as the desire to create large and unobstructed spaces adaptable to varying needs of participants that made the arch type of roof a particularly pleasing and economical solution.

Consideration was given in the structural design to the probability of prefabrication of the various units on the ground, with subsequent erection in large units. This possibility was recognized by the contractors, and resulted in safer and more economical methods of construction. The construction plan was to fabricate studs and sheathing on the ground in large panels which were then lifted bodily into place. The first wall panel units, 38 ft. high and 132 ft. long, required two derricks to lift them into place. When it was found that this size was too large for economical handling there was a switch to smaller panels (22x40 ft.) which required but one derrick.

Similar methods were employed for placing rafters and other structural elements. The timber arches of 200-ft. span were fabricated on the ground and raised bodily to final position, the entire setting operation for each arch requiring only about 30 min. (*ENR*, Jan. 20, 1938, p. 114). Even the exterior sheathing and studding of the 400-ft. central tower was prefabricated in panel units which were lifted bodily into final position. These prefabrication and erection schemes very definitely reduced hazard, and also resulted in a saving of time and expense.

Joint types and timber grades

In the design of timber structures several types of timber joints were used. Of these the more important were:

A. Rod-and-block type, commonly known as the Howe type, used in large span arches and trusses.

B. Strap-and-pin design, in which timber members are used for reversible tensile and compressive stresses; the joint detail consists of steel straps connecting to a common pin bolt (*ENR*, Aug. 4, 1938, p. 151). The straps are fastened to the timbers by flush type shear plates and bolts. This type of joint was used in high tower structures and in certain arches and trusses. In some instances, steel gussets were used in lieu of the strap and pin bolt detail.

C. Modern ring connectors connecting timbers by means of split metal rings. This type of joint was used in purlin trusses, braces, towers, and in general wherever the connecting loads ranged from 15 to 60 kips.

In general, the new strap-and-pin construction was found to produce structures of more pleasing appearance than did the older rod-and-block type. Before contracts were let discussion arose in the department of works as to which was the more economical of the two types. Because fabrication cost on the more modern type was not well known to contractors, it was thought advisable to prepare plans of the main exhibit palaces for both the rod-and-block type and the strap-and-pin type. The low bid on buildings of some 1,000,000 sq.ft. of floor area (the work including pile foundations, wood studs for the walls, wood trusses, wood floors, wood sheathing for the roof, together with roofing, wall sheathing, sheet metal roof leaders and minor painting) was, roughly, $1,181,000 for the rod-and-block type and about $1,200,000 for the strap-and-pin type.

It was required that all lumber bear official grademarks of the West Coast Lumbermen's Association. Studs and plates, rafters, and set-back walls were in general "No. 1 dimension." Flooring for all of the palaces was 1½x6-in. "*C* grade matched flooring," surfaced to 1 5/16 in. Although Douglas fir was used mainly, hemlock was permitted for flooring at the option of the contractor. Exterior faces of all side walls were covered with a special sheathing milled from 1x6-in. No. 1 boards, in which grooves were ploughed out to hold the plaster by a milling process done at the site. The end joints of the sheathing were cut to center on the studs and were nailed to each stud with two 8-*d* galvanized nails. Roof sheathing was 1¼x8-in. "No. 1 boards." Lumber for arches and purlin trusses was "select structural grade." Compression and tension members, 4 in. and thinner, were "select structural joist and plank;" compression members 6x6 in. and larger were "select structural posts and timbers."

Chiefs of the several construction divisions are as follows: structural engineering, John J. Gould; specifications, Albert J. Evers; estimates and, later, construction, H. C. Vensano. The Public Utilities Commission of San Francisco, the sponsor named in the PWA application, was the contracting agent for much of the timber structural work.

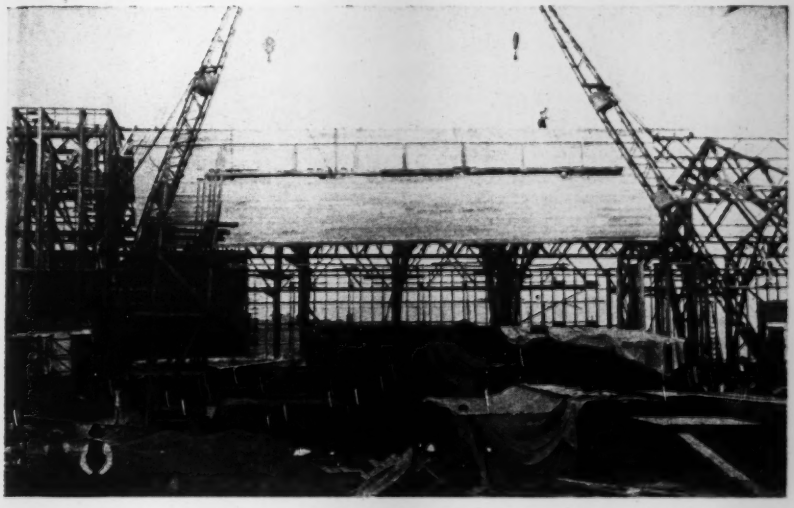


Fig. 3. Prefabrication of wall panels and erection in large units reduced hazard and cost of construction.

Utilities for Millions of Visitors

Concentrated but diversified utility requirements were met in each case with a view to the very special service

ALL THE UTILITIES needed in a great city had to be provided for the Exposition and the work had to be done with dispatch. The start was from scratch: a barren fill, soaked with salt water, had to be completely equipped in less than a year with water supply, both domestic and high pressure, storm and sanitary sewers (some of which operate under pressure), electricity and gas systems and particularly complete facilities for transportation of all kinds. Construction on the utilities started early in August, 1937, and in less than 12 months all but the paving had been put in.

Determination of the quantity of water needed was made after study of the proposed uses at this exposition in the light of experience at other expositions. The water supply, from San Francisco's city mains, is pumped across the suspension spans of the Bay Bridge through a 10-in. cement lined, welded steel pipe, with flexible joints at the bridge towers, and delivered to a 3,000,000-gal. reservoir excavated in the rock on Yerba Buena Island. (*ENR*, Dec. 30, 1937, p. 1050 and Sept 9, 1937, p. 428). From the reservoir (El. 262 ft.) water flows by gravity to the fair grounds through a 20-in. pipe laid in the connecting causeway. The Bay Bridge pumping plant has two main motor-driven centrifugal pumping units with capacities of 1,900 and 1,400 g.p.m. respectively. Total cost of the pumping plant, pipe line across the Bay Bridge to the reservoir, and the reservoir itself, was about $251,000.

Water for fire-fighting

The high pressure water system operates under a static head of 110 lb. per sq.in. and maintains a residual pressure of 100 lb. at hydrant outlets when supplying 20 fire streams of 250 g.p.m. each to a concentrated fire area. The site of the reservoir on Yerba Buena Island was selected at an elevation such as to make unnecessary the use of pumpers in the fair grounds. There are 200 high-pressure fire hydrants known as the "California type," located at strategic points in the built-up area. For emergency, a 10-inlet manifold and wharf have been put in at the southerly end of the fill where the San Francisco fireboat can pump salt water into the high pressure system at 175 lb. per sq.in. In the event of a fire of major proportions, requiring the use of the fireboat, provision has been made whereby the domestic water supply will not be contaminated by the salt water pumped from the bay. The total cost of the high pressure water system was about $160,000.

Water for domestic uses

The domestic water system also furnishes the supply for garden irrigation, fountain and lagoon operation. Again for emergency purposes, provision has been made for the flushing of all toilet fixtures by salt water pumped from the Bay if an unexpected demand for fresh water becomes greater than the supply. The domestic system is maintained at a pressure of 60 lb. per sq.in. by pressure reducing valves, and it is estimated that during the period of the Exposition it will deliver an average of 1.8 and a maximum of 3.5 m.g.d. The total cost of the domestic water distribution system, exclusive of service connections to participants, was about $48,000. In addition, something like $15,000 will be expended for sprinkler systems in planted areas.

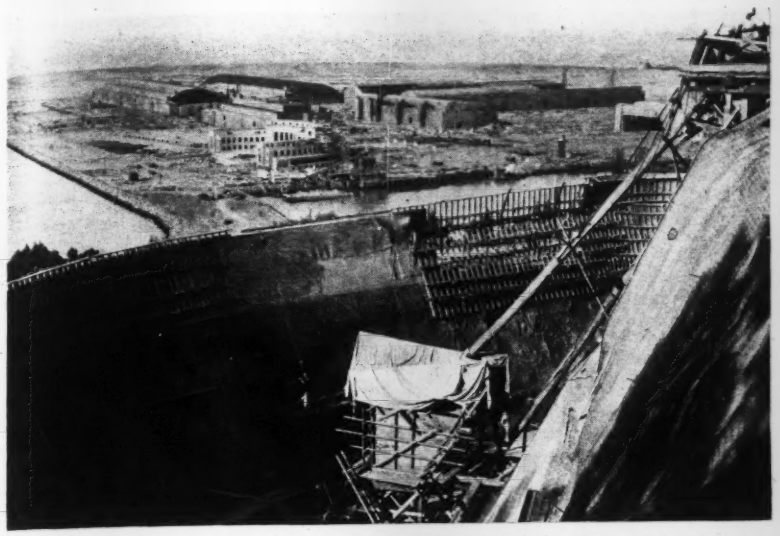
Separate collection systems are used for storm drainage. There are ten independent gravity storm drains fed by 400 catch basins and 200 building leaders. The discharge is directly through the seawall into the bay. Soon after the storm drains were completed they were used temporarily for the disposal of pumped drainage and other waste material. The total cost of the storm sewer system, in which wood stave pipe was used chiefly, was about $190,000.

Sanitation

The preparation of plans for sanitary works involved several unusual features. The flat topography and comparatively low elevation of the site (El. 13 above M.L.L.W.) provide insufficient vertical range for gravity flow in the sewer mains, thus necessitating pumping. Collection is by short gravity runs to 13 concrete sumps located at suitable points with reference to buildings. Each sump is equipped with duplicate pumping units which deliver sewage to a single steel force main extending throughout the width and length of the Exposition area and discharging at a comminutor plant at El. 22.

In this plant solids are chopped up to ¾-in. size or less, and the effluent then flows by gravity to a submerged outlet at a depth of 40 ft. in the east channel, 1,000 ft. off shore from the northeast corner of the site. Disposal will be by dilution in the tidal waters of San Francisco Bay, which discharge through the east channel at an average rate exceeding 100,000 sec.-ft. with velocities of 2 to 4 ft. per sec. The comminutor plant and outfall line are designed for a maximum flow of 3,000 g.p.m.

Before plans and specifications for sewage disposal were prepared, a thorough study of the problem was made, including exhaustive current velocity determinations with submerged floats, milk bottle tops, urinine *N*. dye, and by the development of vertical velocity curves from sur-



A 3-m.g. reservoir on Yerba Buena Island affords storage whence water flows by gravity to the exposition on Treasure Island in the background.

face to bottom based on current meter measurements. The total cost of the sanitary sewers, including force mains, gravity laterals, treatment plant and outfall, but exclusive of service connections, was about $85,000.

There are fifteen public toilet locations on the grounds, comprising a total of 1,624 plumbing fixtures. Toilet and rest rooms are provided with mechanical exhaust ventilation, which makes 10 complete air changes per hour. The typical unit consists of 15 fixtures, divided as follows: for women, 7 water closets and 3 lavatories; for men 2 water closets, 2 urinals and 1 lavatory. Selection of this typical unit was made after careful checking of experience at the Century of Progress Exposition: there a slightly different arrangement was reported to have given unsatisfactory results, which the plan at San Francisco is expected to avoid.

Fountains and lagoons

Fountains of various types have been designed for 6 main locations. In the south garden, the main jet is 5 in. in diameter and 75 ft. high, with 8 smaller jets surrounding it. In the east court, the fountain consists of a large number of small vertical and angular jets. In the north court, the water display is primarily a large cascade. All of the fountains use recirculated fresh water, most of which is filtered. The total volume of water in all fountains is approximately 800,000 gal., circulated with 15 centrifugal pumps, at the rate of 32,000 g.p.m. with a motive power of 500 hp.

The main lagoon, which holds about 7,000,000 gal., is provided with two 6,000-g.p.m. 40-hp. circulating pumps and a filter to handle 450 g.p.m. It is expected that this water, in addition to being circulated and filtered, will be treated to prevent the formation of algae.

Electrical services

The expenditure by the Exposition company for electric service facilities and for decorative and ground lighting will exceed $1,000,000, more than half of which will be for exterior lighting. Electricity will be supplied by the Pacific Gas and Electric Co. which is installing three submarine cables from the Key System mole to the Exposition grounds. These cables will extend through Oakland to one of the company's power stations in which a 45,000-kw. turbo-generator is now being installed—a service connection which is expected to make interruptions to service highly improbable. From this section 11,000-volt cables will extend to a main step-down substation in the easterly hangar on the grounds. This substation will have modern oil switches and protective equipment, and its 16,000-kva. transformers will be of the type that automatically maintain constant voltage. A high voltage distribution system (4,000 volts, 4-wire, 3-phase with grounded neutral) is being run underground to 20 concrete transformer vaults at various points on the grounds. The cables are of special rubber, buried directly in the ground without conduit, except for certain locations where they are laid under courts. Within the palaces the plan is to supply secondary feeder buses run on racks under the floors. The feeders will be protected by fuse safety switches in the vaults. Taps will be made from the nearest bus to supply each exhibitor.

All secondary distribution to supply lighting standards, isolated decorative structures, and small exhibit stands will be special 600-volt rubber insulation, run undergound without conduit. The secondary circuit will be 220-volt, 4-wire, 3 phase. Decorative lighting circuits will be supplied from separate transformers located in the underground vaults. Feeders will be run to decorative circuit boxes on exterior walls, on roofs, and on individual decorative structures.

The concession area will be supplied from an 11,000-volt feeder to several outdoor transformer substations. Individual exhibit buildings will, in general, be supplied from the 4,000-volt distribution system to their own transformer vaults.

Decorative lighting separate

The entire decorative lighting load which will be served by facilities separate from those supplying interior lighting and the exhibitors, will be controlled from the main substation. An emergency lighting system supplied from storage batteries will be installed and so laid out that none of the palaces, courts or main arteries will be dark in case the power supply fails.

The peak demand was estimated at 14,000 kw. although it is thought this may go as high as 16,000 kw. The monthly consumption of electrical energy is estimated to be 4,000,000 kw.-hr. The present plans contemplate about 8,000 flood-lighting units and 900 lighting standards of various types.

C. H. Lee is chief of the division of water supply and sanitation, Wm. E. Leland of the division of mechanical engineering, Wm. Van Bokkelen of the division of electricity and Earl F. English is the consultant on electricity.

FIG. 1. SUNDAY CROWDS VIEWING CONSTRUCTION SYMBOLIZE THE TRANSPORT PROBLEM

Roads and Transportation

Mid-bay location imposed unusual transport problems but ample facilities are provided for 200,000 visitors per day while 400,000 can be handled. Ferries designed to carry 26,000 persons per hour

FACTORS that complicated development of the most effective plans for movement of visitors to and from the Exposition grounds were (1) location of the site in the middle of San Francisco Bay and (2) the fact that the interurban tracks on the Bay Bridge are on the far side of the lower deck whence connections for special trains to the grounds would be particularly difficult. Attack on the transportation problem began some three years ago with the result that the important decisions were made early, construction is well along and, before opening date, the system for transporting visitors will be functioning fully. Mass transportation to the grounds will be by ferries from both sides of the bay, although private cars as well as motor buses will have continuous access via the bridge. None of the entrants will come on foot as pedestrians are not allowed on the Bay Bridge.

A major hurdle in the planning was passed when decision was made to put in facilities for handling 400,000 visitors on a peak day, this number to be the total coming by ferry and by motor vehicle. Construction on ferry slips and on some of the roadways on Yerba Buena Island had to be started before the transportation program as a whole was worked out; how the plans were coordinated is outlined in the following.

The general system determined upon is indicated by accompanying illustrations (Figs. 2 and 3). Access to the grounds will be by ferry from the ferry building in San Francisco to the west ferry slips (ferry trip about 2 miles), from the Key System pier on the Oakland side to the east slip (ferry trip about 1.6 miles), and by auto or bus from either San Francisco or Oakland. The trip by motor vehicle will be via the Bay Bridge to Yerba Buena Island and thence over the road system and causeway joining the island to the fair grounds. Vehicles from San Francisco will pass through the island tunnel to avoid a left hand turn in leaving the bridge.

The design of the roadways around the steep sides of Yerba Buena Island presented problems which were solved by an intricate ramp and overhead system without traffic crossings or left-hand turns. On Yerba Buena Island the roadway is 64 ft. wide and of this about half is temporary construction which will be removed after the Exposition, as will certain ramps needed only during the heavy traffic. There will remain a permanent road and bridge structure from the lower deck of the Bay bridge down to the future airport.

Total cost of the roadway, bridges and surfacing, both permanent and temporary, is about $500,000. The work was designed to meet the approval of the navy department, the Bay Bridge authorities, the public utilities commission of San Francisco, and the department of commerce (the last named has jurisdiction over facilities of the lighthouse district on the island). The road contains several parts, respectively, of structural steel, timber and concrete.

Exposition attendance estimates

For purpose of transportation analyses, average daily attendance at the Exposition was estimated at 83,000 people, or a total of about 24,000,000 for the entire February-to-December period. The largest number on a single day was set at 400,

000. A study of records at the Panama International Exposition and the Century of Progress led to the conclusion that on about one day per month the attendance would exceed 200 per cent of the average. It appeared further that entrance and exit facilities would have to be designed with special consideration for Saturday, Sunday and holiday conditions.

It was held to be inadvisable to provide facilities operating to and from the Exposition of a capacity great enough to transport passengers with no considerable delay on the peak days. On the other hand it was deemed necessary to provide such facilities that definite inconvenience of patrons would not occur too frequently. For reasonable transportation facilities, an attendance of 166,000 or 200 per cent of the estimated daily average was assumed, with the expectation that on not more than nine days would this number be exceeded. From a study of other Expositions, it is believed that the maximum hourly entrants might, under extreme conditions, reach 20 per cent of the daily attendance, and a maximum for exit might be 23 per cent.

The Chicago Century of Progress exposition had several parking spaces near the site. It also had street car, interurban train, bus and taxicab service. Also a number of persons undoubtedly walked from nearby hotels and residences or from automobiles left farther away than the nearby parking spaces. In the case of the Golden Gate International Exposition, with automobile attendance limited by parking capacity on the grounds (12,000 cars) and with no pedestrian access whatever, it was believed reasonable to estimate traffic distribution as follows: 20 per cent by private automobiles, 2 per cent by taxicabs, and 78 per cent by mass transportation.

Fig. 2. Vicinity map showing highway and ferry access to the exposition grounds.

Estimates indicate that the maximum number of people actually on the grounds at any one time should average 70 per cent of the total number of entrants. If this percentage is applied to automobile parking, the space will accommodate 17,100 cars entering per day. At an average of 2.5 persons per car, there might be a maximum attendance of 42,700 persons per day via privately owned cars. A limiting feature in attendance by private automobiles is the maximum rate of exit to the Bay Bridge The bridge approaches from the exposition provide a maximum of four lanes to the upper deck, equally divided between San Francisco and the East Bay.

Stop-and-go signals are to be installed, and these will have the effect of restricting peak exit from exposition to bridge to an average of 25 seconds per minute. On this basis, the exit per lane would be 500 per hr. or 2,000 for the four lanes. This exit period might be increased during the evening, or when bridge traffic is low, to 35 seconds per minute, which would allow 700 automobiles per hr. per lane, or a total of 2,800 per hr. as a maximum. This number averages 7,000 persons per hr. or about 17 per cent of the 42,700 daily attendance, thus practically balancing automobile parking facilities and capacity of the bridge approaches.

Ferries for mass transportation

The controlling feature in the transportation facilities was taken to be the maximum exit rate which, on a day when attendance was 166,000, would call for a maximum hourly movement by privately owned automobiles of 6,640 people (2,656 cars) and by mass transportation (ferries) of 25,896. The figures for a peak day with an attendance of 250,000 indicates 7,150 persons by automobile and 41,800 by mass transportation in the maximum hour. From these considerations, it was concluded that

Fig. 3. Vehicle traffic for San Francisco Golden Gate International Exposition next year will be handled by this Bay Bridge connection, which eliminates all left turns.

Fig. 4. Ferry slips into which 3,600-passenger boats will bring visitors at a maximum rate of 32,400 per hour.

mass transportation facilities adequate to handle at least 26,000 persons per hr. from the exposition should be provided, and that the facilities should be sufficiently flexible to handle larger groups without tying up other traffic.

The Key System now operates three passenger ferries at a speed of 15 m.p.h., with a capacity of 3,600 or more per boat. The Southern Pacific Co. is operating six passenger ferries at a speed of 12 m.p.h., of average capacity exceeding 3,600 per boat. Check of the rates at which passengers board or leave the ferries indicated a rate of 26.9 persons per ft. of apron width per minute. The aprons of the Exposition slips have a net width of 19.5 ft. permitting the loading or unloading of 3,600 persons per boat in something less than 7 min.

Arrangements have been made with the Key System to undertake the mass transportation for the Exposition company. A fleet of at least nine boats will be available, and the Key System agrees with the Exposition's belief that the westerly slips alone can handle 32,400 persons per hr., corresponding to a crowd of about 200,000 per day. These figures are exclusive of the easterly slip which will be modified from the present freight slip design to accommodate passenger ferries from the East Bay. The capacity for a single slip on the east side will be approximately 14,000 passengers per hr., based on 4 boats with an average of 3,600 passengers each.

Bridge tolls will be collected from motor vehicles by the Toll Bridge Authority separately from the collection for admission to the grounds. Bridge toll gates are being constructed on the supplemental road on Yerba Buena Island while gates for taking admissions to the grounds will be operated by the Exposition company at the point where the causeway joins the grounds.

The three passenger ferry slips on the westerly side, and the single freight slip on the easterly side were constructed with the aid of PWA funds, at a gross cost of $499,000, including the slips themselves, mechanical equipment, pile covering and structural steel.

Roads on the grounds

Shortly after the completion of the dredged fill, it was necessary to provide a system of service roads for the further prosecution of the work. These encircled the site and were located where they would be the base of the proposed intramural system to be used during the Exposition. They were made of water-bound macadam with a 7-in. base, and during a year's construction period successfully withstood the heaviest kind of traffic. At present, the service roads are being extended, again with a view to their final use for intramural purposes. The service roads are uniformly 24 ft. in width with the exception of short runs 12 ft. wide in the concession area.

The finished roadways for the most part are 100 to 120 ft. wide, and it was recognized that it would be most unwise to put in anything other than heavy duty service roads until the tree planting schedule had been completed. Many of the trees weigh more than 50 tons each—much more than could be moved over pedestrian roads without damage. Accordingly, heavy horticultural hauling was first completed and then contracts were let for roadways and pedestrian pavements on either side of the service roads.

To provide the necessary paved area for pedestrians, about 4,500,000 sq.ft. of sand fill had to be stabilized with asphalt. Preliminary estimates indicated that such work could be done in large areas with the most advanced equipment for about 3½ c. per sq.ft. On this job, however, the area was so divided into paths, spaces between trees, etc. that equipment designed for unobstructed areas was unsuited to much of the work. Contracts were let on a basis of slightly more than 5 c. per sq.ft.: 1,000,000 sq.ft. was to be done by hand rolling and the remainder in the usual way. All rolling was to be done with rubber-tired equipment.

The work consisted of putting in headers and curbs and stabilizing the fill with emulsified asphalt to a depth of 3 in.; the quantity used was about 1¾ gal. per sq.yd. Exact proportions of sand and asphalt were determined by the following formula based on aggregate samples taken from each 2,000-sq.yd. area:

$$E = 0.03a + 0.06b + 0.03c$$

where E = per cent, by weight, of emulsified asphalt required to coat a unit weight of dry sand.

a = per cent of sand retained on a No. 10 standard testing sieve.

b = per cent of sand passing a No. 10 and retained on a No. 200 sieve.

c = per cent of sand passing a No. 200 sieve.

All intramural transportation will be supplied by the Key System, the company which operates the ferries that will handle the general mass transportation. Modern, streamlined motor cars and trailers, specially designed for this service, have been made to harmonize with the elephant motif used in some of the architecture. There will be 18 or more trains

each consisting of a motor unit powered with a gasoline engine, and three trailers. Each trailer will have longitudinal seats for 20 passengers or 60 per train. Train speeds will be limited to about 6 m.p.h.

Fences will be built along the service roads to keep vehicular traffic (including intramural trains) off pedestrian pavements. Finally, both the stabilized sand and the macadam roads will be covered with a uniform ½-in. surfacing of colored aggregate and binder just previous to the opening of the exposition. Painted lines on boards attached to headers for the service roads will indicate the line of demarcation between service and pedestrian roads.

John B. Leonard is chief of the division of roads and bridges; I. S. Shattuck is chief of the division of transportation, and L. S. Ready is consulting engineer on transportation.

Moving Trees Wholesale

Some 3,000 full-grown trees, up to 65 ft. in height, and 35 tons in weight, are being planted on Treasure Island, five contracting companies being engaged in the $315,000 operation. At the nurseries, as much as 40 mi. away from the Exposition, heavy "root boxes," ranging up to 10 ft. square, are built around the trees before they are moved. Motor trucks and low-bed trailers haul them to barge loading points whence they are towed to the island. Unloaded by a floating, stiffleg derrick rig, the trees are placed on 10 x 10-ft. steel sleds and, with two tractors pulling and one pushing, they are delivered to the selected locations where the tops of the root boxes are set flush with the ground surface.

The larger trees will remain in their boxes during the 40 weeks of the Exposition so that subsequent removal will be simplified. Trees that will not interfere with the ultimate use of the island as an airport are to be left permanently in place. Paving of Exposition roadways was deferred until the heavy trees had been placed. The tree planting operations were carried out in a 4-month period ending Sept. 15. The entire landscaping program for the Golden Gate International Exposition will cost $1,500,000. Julius L. Girod is chief of the bureau of horticulture.

Fig. 2. Unloading a 65-ft. palm tree on Treasure Island.

Fig. 1. Tractors, working in pairs of threes, placed large trees at the rate of 25 per day.

FROM FIELD AND OFFICE

Working problems and time-saving methods . . . Edited by Charles S. Hill

Graphics for Vertical Curves

GEORGE H. DELL
University of Illinois, Urbana, Ill.

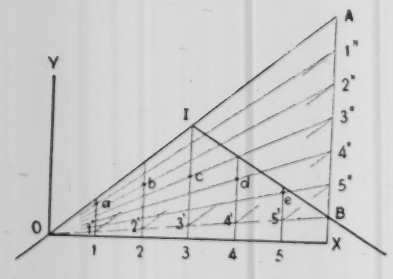
For effecting a transition of gradient on a roadway, the curve that is generally used is the parabola in which the "length of the curve," or the horizontal distance between the end points, is bisected by the point of intersection of the end tangents.

With the origin of coordinates at *O*, as illustrated, the general equation of the parabola in question is

$$y = g_1 x + \frac{g_2 - g_1}{2L} x^2,$$

where g_1 and g_2 are the slopes of the tangents *OIA* and *IB*, respectively, and *L* is the length of curve.

A correct and useful method of plotting this parabola is that illustrated which shows the relative slopes of the given tangents, *OIA* and *IB*, the length of the curve being represented by the distance *OX*. To determine graphically the ordinates to the parabola at the stations indicated by the numbers 1, 2, 3, etc., the vertical *AB* is first subdivided into intervals *A1″*, *A2″*, *A3″*, etc., which are directly proportional to the abscissae *O1*, *O2*, *O3*, etc., respectively. This may be done directly by scaling along *AB* or, graphically, by drawing lines though the points *1′*, *2′*, *3′*, etc., (the points where the verticals through the given stations intersect the chord *OB*), parallel to the tangent *OIA*. The chords *O1″*, *O2″*, *O3″*, etc., are then drawn, and the intersections of these chords with the corresponding verticals through the given stations mark the location of the required points on the curve, as shown by *a*, *b*, *c*, etc.



Graphical method of calculating points on vertical curves.

This construction, in addition to providing a simple means of plotting vertical curves on office profiles, is useful in two other respects, namely (1), if drawn to a suitable vertical scale, it constitutes an accurate method for determining the elevations graphically, and (2) it forms the basis of a convenient method for calculating the elevations arithmetically.

• • •

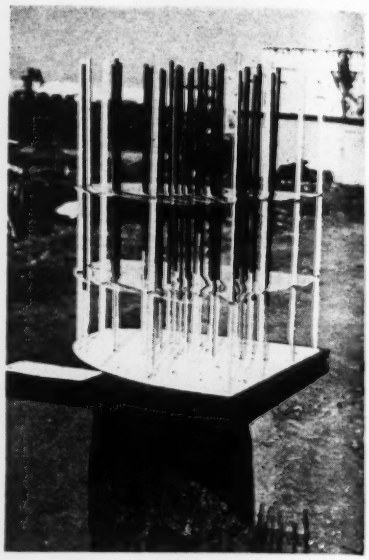
Model of Test Borings

HENRY D. HAMMOND
Engineer, Standard Drilling Co., New York, N. Y.

The model shown present graphically in three dimensions the conditions disclosed by test borings made for the exhibit building being erected for General Motors at the New York World's Fair, 1939. It was of great assistance to Nelson M. Doe, of the Turner Construction Co. (who devised and made it) in explaining to visiting officials, many of whom were not engineers, the subsurface conditions, and their connection with the foundation work required for the building.

The borings were made as a guide for the pile driving, first to determine the proportions of pile lengths to be purchased and second to settle any question whether piles at any given location which had developed an apparently satisfactory resistance in driving actually had a proper penetration in good bearing material.

Over the site a heavy cinder fill had been placed on top of harbor mud of considerable thickness, which rested on the original bottom consisting mostly of sand with some streaks of clay and a little gravel. The contours of the divisions between these materials is shown on the model by painting different colors on scale lengths of small round sticks, one stick being made for each boring. A wood base, cut to scale size and shape of the plot, was used to lay out the exact locations of the borings. The stick representing each boring was driven into a small auger hole bored in the base at the location of that boring. Each stick was cut so that when in place its top stood at the ground surface to which the plot had been graded at the start of construction.



Painted sticks set in base made to plot shape indicate materials disclosed by test borings.

By looking through the model, from any side, it was easy to observe during driving what materials the piles were going through at any part of the plot, and how far they would penetrate suitable bearing material, without doing the mental reconstruction and visualizing required when examining a set of blue prints. To assist further those inspecting the model, two sheets of celluloid were cut to the shape of the plot, on the same scale as the base (30 ft. to the inch) and perforated at the location of each boring. These could then be slipped over the sticks and secured at the approximate average surfaces of the mud and the underlying sand.

The borings were made for the Turner Construction Co., general contractors for the work, by the Standard Drilling Co.

$3 to $5

paid on acceptance for items suitable for the pages of From Field and Office